212 Ketter Hall, North Campus, Buffalo, NY 14260-4300 Fax: (716) 645-3733 Tel: (716) 645 5400 X 16
http://www.nees.buffalo.edu

1. Abstract / Introduction

2. Description of laboratory facilities

The Department of Civil, Structural and Environmental Engineering at the University at Buffalo has an extensive earthquake simulation, structural, and geotechnical engineering testing facility that is a key node in a nationwide earthquake engineering "collaboratory" - the National Science Foundation's "George E. Brown, Jr. Network for Earthquake Engineering Simulation" (NEES). The entire lab facility consists of four main laboratory rooms, two earthquake laboratories, identified below as Testing Area 1 and Testing Area 2, a Receiving Area and a Fabrication Area, located side by side within Ketter Hall. In addition to these laboratories, Ketter Hall also houses many of the Civil and Structural Engineering faculty offices and a number of smaller laboratories in structural and geotechnical engineering used for research and instruction. These laboratories are also briefly described herein. Figure 2-1 presents a plan drawing of the laboratory facilities.

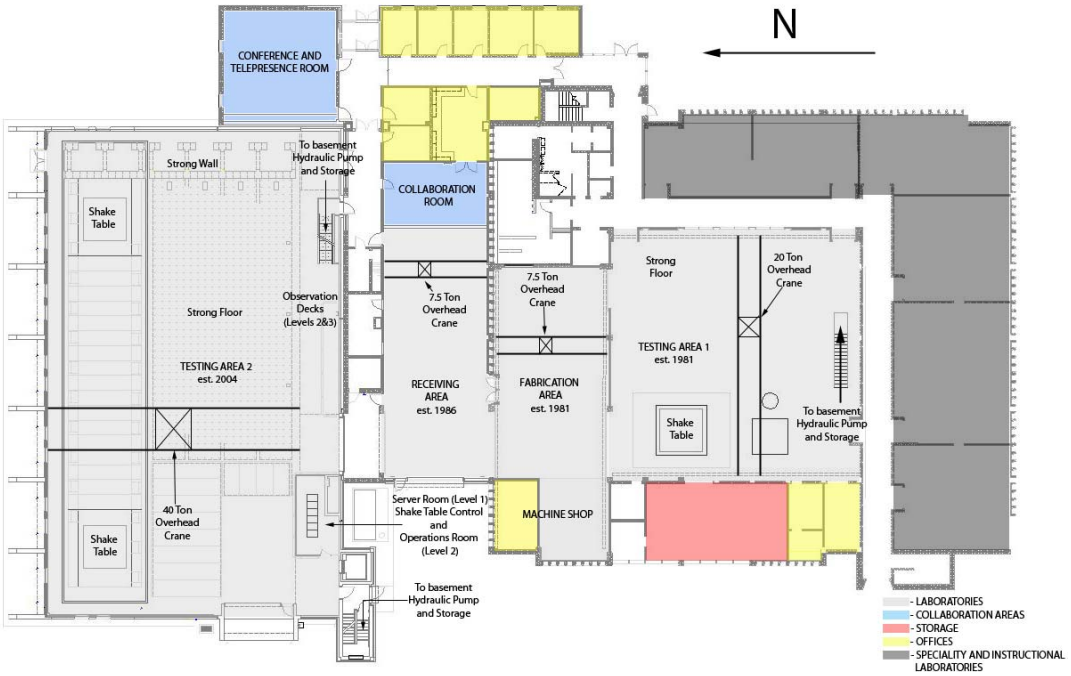


Figure 2-1: Plan of Laboratory Facilities

2.1. Structural dynamics and earthquake simulation testing:

2.1.1. Testing area 1 – Old Lab

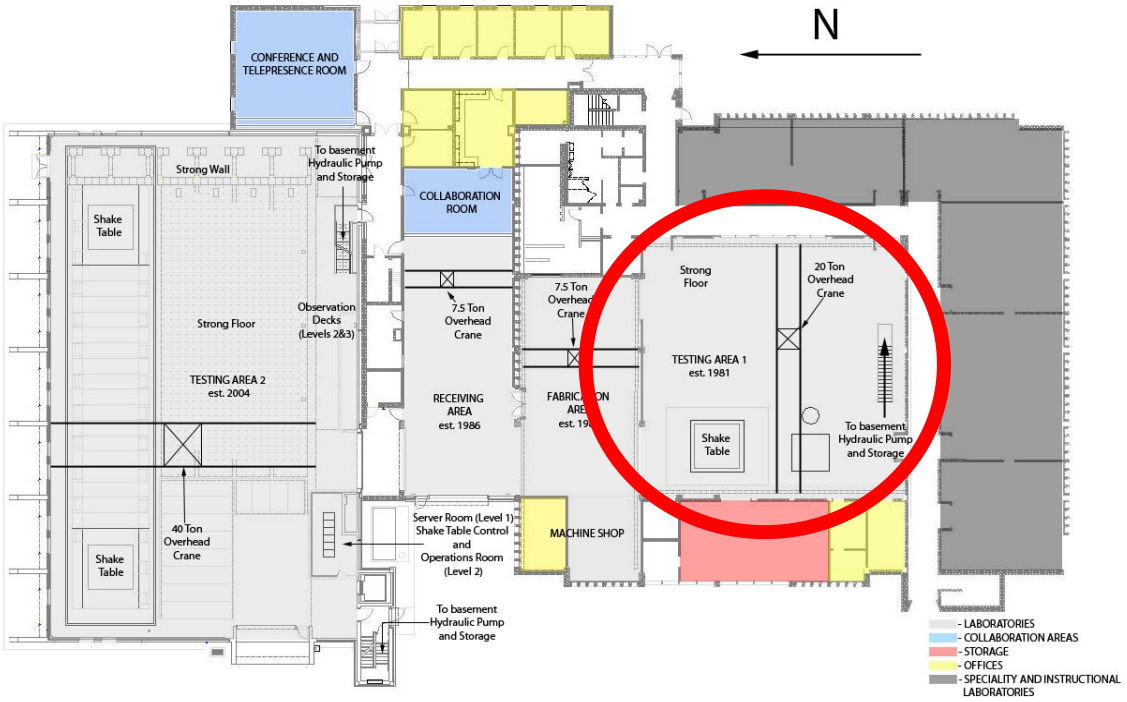


Figure 2.1.1-1: Testing Area 1 within Plan of Laboratory Facilities

The Testing Area 1 of the Structural Engineering and Earthquake Simulation Laboratory is the smaller of the two main earthquake laboratories located within the building. Figure 2.1.1-1 identifies Testing Area 1 within the general plan of the laboratory.

It consists of a large rectangular room approximately 70 ft. (21m) long, 65 ft. (20m) wide, and 30 ft. (9m) tall, enclosing a large strong floor area to which large scale or full-sized specimens and structural assemblages can be attached for quasi-static and dynamic testing. Portion of the area is dedicated to a seismic simulator and a Single-Degree-of-Freedom shake table. A Number of reaction frames are also available for providing lateral support. The area is accessible through a 20 ft. (6m) wide by 13 ft. (4m) high roll up door, and a 12 ft. (3.7m) wide by 12 ft. high (3.7m) roll up door. Both doors are located at the north end of the laboratory and open into the fabrication and receiving areas, which make for excellent accessibility to the loading bay. The laboratory has an overhead bridge crane which is capable of moving materials and test units to any location within the seismic laboratory. Also available within this laboratory are two bearing testing machines. The Large Bearing Testing Machine has been developed and primarily used for commercial testing of large bearings. The Small Bearing Testing Machine is highly versatile and is capable of applying simultaneous compression or tension, shear and rotation on specimens. An office is located in the southwest corner of the laboratory which houses the control center for the seismic simulator. A storage room is also located in this vicinity which stores instruments and data acquisition equipment.

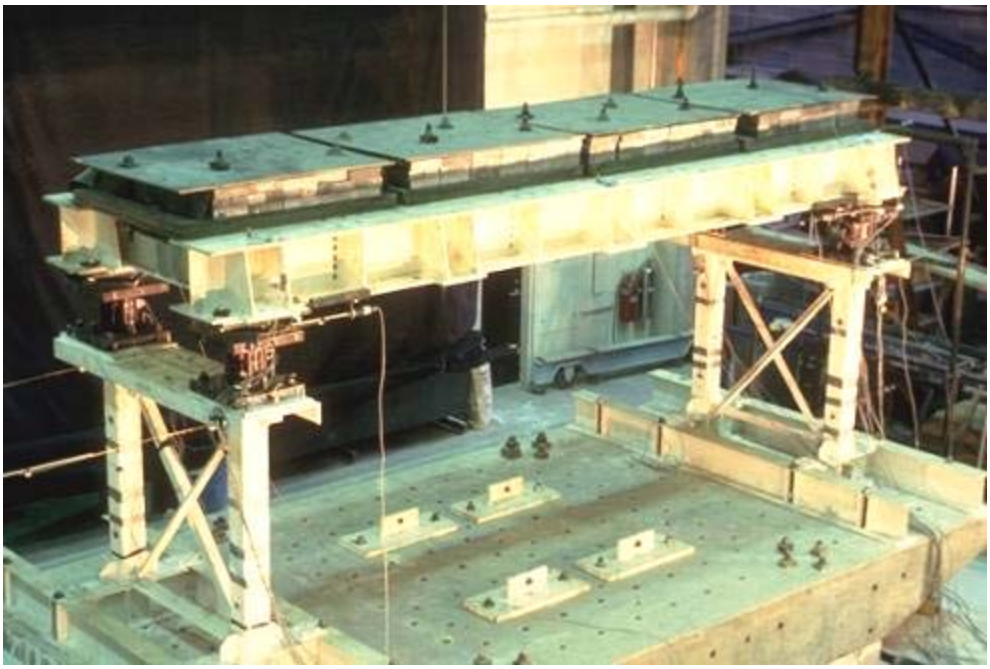


Figure 2.1.1-2: **Shake Table O in Testing Area 1 with extension block**

2.1.1.1. Shake Table O

A portion of the seismic lab is dedicated to a 12 ft. (3.7m) by 12 ft. (3.7m) seismic simulator. An opening in the floor allows for a shake table pit to enclose the simulator as well as its mechanics. This shake table has been in use at the University at Buffalo for nearly 20 years. In 2004, it has been refurbished with a new controller and re-built actuators. Figure 2.1.1.1-1 and Figure 2.1.1.1-2 present plan, elevation and isometric views of the shaking table and a trench around it. Details and specifications of the seismic simulator are presented in the laboratory equipment section.

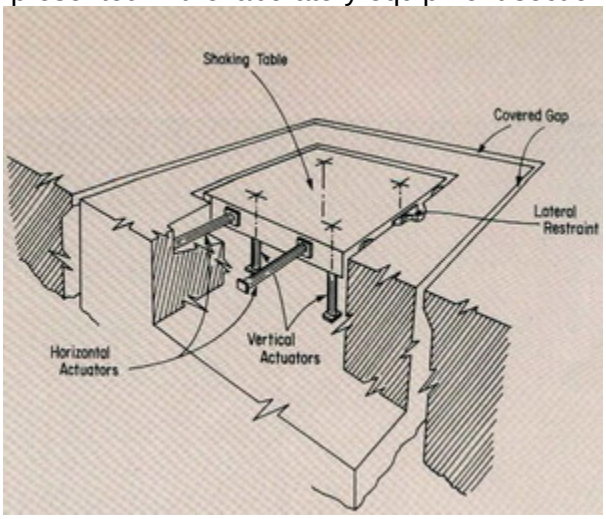


Figure 2.1.1.1-1: View of the Shake table and the trench

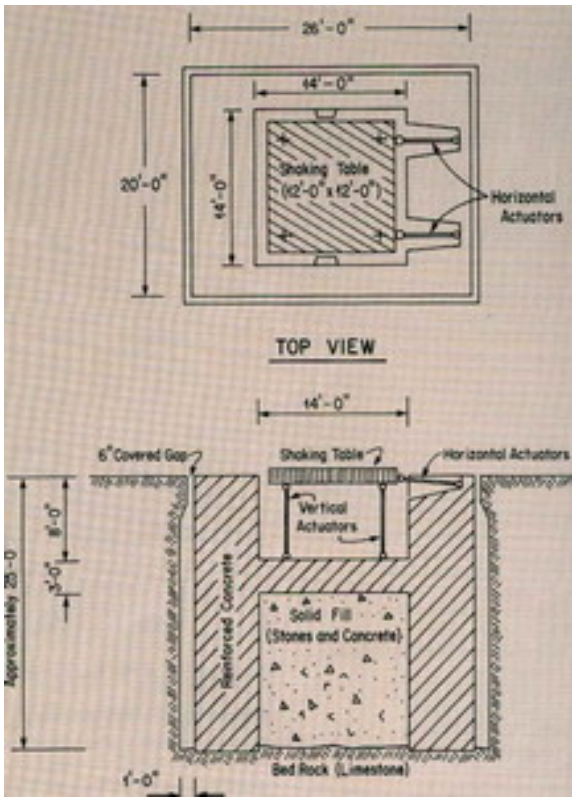


Figure 2.1.1.1-2: Plan and elevation view of the shake table

2.1.1.2. Strong floor O

The test floor is a five cell reinforced concrete box girder 40 ft. (12.2m) long, 60 ft. (18.3m) wide, and 8 ft. (2.5m) overall in height. The thickness of the top test floor slab is 18 in. (46 cm). Tie down points consist of (4) 2 ½" holes which are arranged symmetrically in both directions. Each tie down point has an axial load allowable capacity of 250 kips (1112kN). Figure 2.1.1.2-1 presents a view of the strong floor including the layout of the tie down points.

Figure 2.1.1.2-1: View of the strong floor with tie down points

2.1.1.3. Gantry crane

Testing Area 1 has a 15ton / 33 kip (~150kN) capacity overhead bridge crane which is capable of moving materials and test units to any location within the seismic laboratory. Operation by Staff or Trained Personnel ONLY!

Figure 2.1.1.3-1: 40Kip Gantry Crane

2.1.1.4. Reaction frames

Located within the laboratory area are several reaction frames that have been fabricated in-house and are used to provide adequate support for lateral loading. The tallest frame can be used to test specimens up to 20 ft. (6m) tall with lateral loads of up to 250 kips (1112kN) at a height of approximately 8 ft. (2.4m) or lower. The frame can also support up to 120 kips (534kN) lateral load applied at a height of 8 ft. (2.4m) or higher. Arrangements are available for developing vertical load in addition to lateral load, and for providing lateral stability to the specimen.

Figure 2.1.1.4-1: Picture of the tallest reaction frame

A second, shorter reaction frame that is also available has been designed for 55 kip (245kN) horizontal force applied at a height of 100 in. (2.54m) above the floor. It is furnished with 55 kip (245kN), ± 6 in. (15.24 cm) stroke, and 90gpm (340.7lpm) servovalve actuator. Specimens may be attached to the strong floor or to a W21 x 50 beam that is attached to the strong floor. The reaction frame may be used with an existing versatile steel portal frame (column W8 x 24, beam W8 x 21, length 100 in (2.54m), height 75 in. (1.9m), with simple connections that can be easily converted to semi-rigid and rigid) to test energy dissipating systems.

Figure 2.1.1.4-2: Picture of the shorter reaction frame

2.1.1.5. Shake table S

Testing Area 1 features also a Single-Degree-of-Freedom shake table. Built by laboratory personnel and students, the table is 3 ft. by 5 ft. (0.9m by 1.5m), has payload of 6 kips (26.7kN), a stroke of ±3 in. (762mm) and can reach accelerations of 0.8g. The table is driven by a 5.5 kip (24.47kN) actuator with two 15gpm (56.78lpm) servovalves. The specimen height is restricted by uplift conditions since the table rides on slide bearings. It is suitable for use with an available three-story, 6 kip (26.7kN) steel model structure.

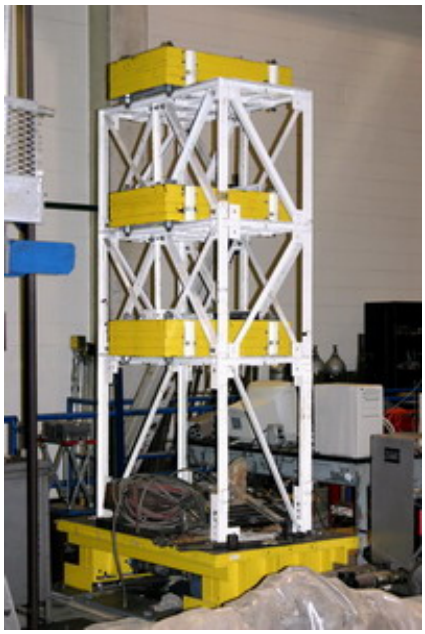


Figure 2.1.1.5-1: Shake Table S in Testing Area 1 with proprietary model

2.1.1.6. Portable Reaction Wall (Block)

Figure 2.1.1.6-1: Picture of Portable Reaction Wall

2.1.1.7. Testing set-ups.

The laboratory is equipped with two bearing testing machines. The Large Bearing Testing Machine has been developed and primarily used for commercial testing of large bearings. It is capable of applying 1600 kips (7117kN) vertical load, and lateral displacement of ±5 in. (125mm) amplitude and 10 in/sec (255mm/sec) peak velocity. Figure 2.1.1.7-1 and Figure 2.1.1.7-2 present views of the bearing testing machine in the testing of a single elastomeric bearing and of a pair of elastomeric bearings.

Figure 2.1.1.7-1: Testing of a Single Elastomeric Bearing in Large Bearing Testing Machine

Figure 2.1.1.7-2: Testing of a Pair of Elastomeric Bearings in Large Bearing Testing Machine

The Small Bearing Testing Machine is a highly versatile machine that is capable of applying simultaneous compression or tension, shear and rotation on specimens. It has a 50 kip (223kN) vertical load capacity (but expandable if a higher capacity load cell is used), ±6 in. (150mm) horizontal displacement capacity, ±2 degrees rotational

capacity and peak speed of over 20 in./sec (0.5m/sec). Figure 2.1.1.7-3 presents a view of the machine in the testing of an XY-FPS bearing in combined tension and high speed shear.

Figure 2.1.1.7-3: Testing of a Bearing in Small Bearing Testing Machine

2.1.1.8. Control room

An office is located in the southwest corner of the laboratory which houses the computer network control center for the seismic simulator as well as office space. A storage room is also located in this vicinity which stores a majority of the data acquisition equipment

Figure 2.1.1.8-1: Control Room in Testing Area 1

2.1.1.9. Equipment

The Test Area 1 of the laboratories is supplied with (2) MTS Hydraulic Power Supplies. Each of the pumps, 506.81 model, consists of (2) discrete hydraulic pumps with individual flow rates of 70 gpm, for a total of 280 gpm. The pumps can be operated individually or in any combination to achieve the required flow rate. The hydraulic supply, manifolds, is available at several stations throughout the laboratory.

Also available are six static actuators (four Parker and two Miller) and eight MTS dynamic actuators.

2.1.2. Testing area 2 – Expansion Lab

Figure 2.1.2-1: Testing Area 2 within Plan of Laboratory Facilities

2.1.2.1. Shake Tables A and B

A set of two high-performance, six degrees-of-freedom shake tables, which can be rapidly repositioned from directly adjacent to one another to positions up to 100 feet apart (center-to-center). Together, the tables can host specimens of up to 100 metric tons and as long as 120 feet, and subject them to fully in-phase or totally uncorrelated dynamic excitations

Figure 2.1.2.1-1: View of Shake table A

2.1.2.2. Reaction Walls

There are two Reaction Walls in Test Area 2, one next to strong floor and one next to the shake table trench.

Physical Dimensions of the Reaction Wall next to Strong Floor are:

- Length: 41'-0"
- Height: 30'-0"
- Thickness: 2'-0"

Figure 2.1.2.2-1: Reaction Wall next to Strong Floor

Physical Dimensions of the Reaction Wall next to Shake Table Trench are:

- Length: 23'-0"
- Height: 30'-0"
- Thickness: 2'-0"

Figure 2.1.2.2-2: Reaction Wall next to Shake Table Trench

2.1.2.3. Strong Floor

Physical Dimensions of the Strong Floor in Test Area 2 are:

- *Length: 79'-0"*
- *Width: 39'-0"*

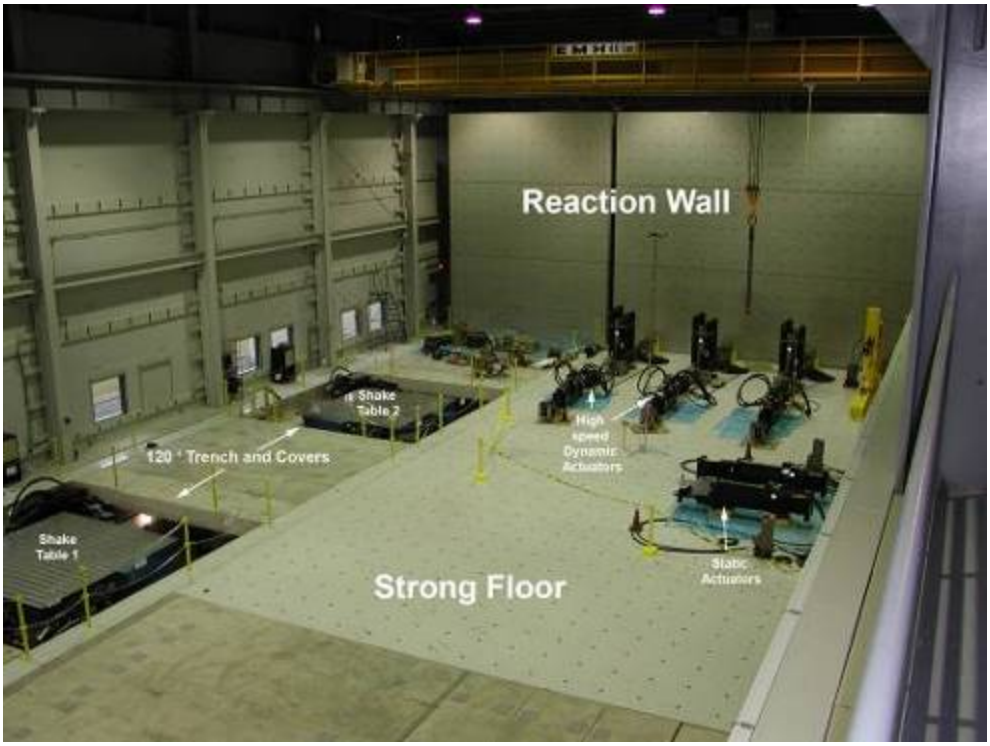


Figure 2.1.2.3-1: Picture of Testing Area 2

2.1.2.4. Gantry crane

Test area 2 is equipped with 40T Gantry crane that spans width of test area and is operated by remote control. Operation is restricted to Staff or Trained Personnel ONLY!

Figure 2.1.2.4-1: Picture of 40T Gantry Crane in Testing Area 2

2.1.2.5. Instrumentation platform

Figure 2.1.2.5-1: Picture of Instrumentation Platform in Testing Area 2

2.1.2.6. Visitors gallery

Two Observation Decks located on 2nd and 3rd level of the lab.

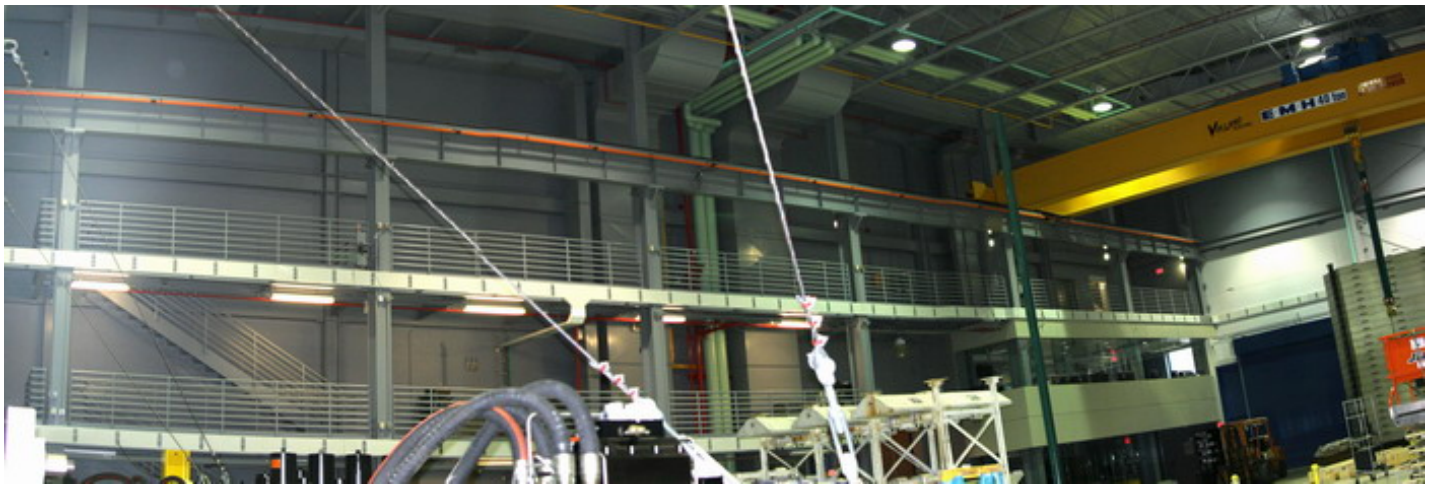


Figure 2.1.2.6-1: Visitors Gallery in Testing Area 2

2.1.2.7. Servers room

All servers are housed in the server room, located on the first floor of the Testing Area 2 lab. Servers are mounted in racks with redundant and backup power supply. Dual gigabit Ethernet connections are provided to each server. There is an integrated LCD/keyboard console to locally administer all servers in the rack.

The Servers housed are:

- NEESpop
- NEES TPM
- Mass Storage (NAS)
- Domain Controllers
- Web Servers
- Email Server

Figure 2.1.2.7-1: Server Room in Testing Area 2

2.1.2.8. Operator deck / room

Elevated Control Room houses Workstations capable of controlling any data acquisition or control system in the lab. These workstations are preloaded with all the necessary software to run any system in the lab. Additionally, software to quickly visualize and analyze captured data is preinstalled as well.

Figure 2.1.2.8-1: Control Room in Testing Area 2

2.1.2.9. Equipment

The pump room, located in the basement of the Testing Area 2, houses four MTS 506.92 Hydraulic Power Supply (HPS) units, each rated at 185gpm (700lpm) flow with 3,000psi (207 bar) working pressure.

Four hydraulic outlet stations are located along the table trench for connection of hoses. Two stations are used to connect to the moveable tables at any one time and any free stations can be used to allow connection of structural actuators to the strong floor along the north side of the floor for certain configurations.

At the strong floor surface, adjacent to the strong wall, four high flow manual distribution manifolds **(**Error! Reference source not found.**)** are located, with four sets of 2 inch hand and check valves to allow connection to the three moveable Hydraulic Service Manifolds. These high flow (800gpm) Hydraulic Service Manifolds with additional accumulation are typically located near the lab reaction wall to provide full flow capacity to the high speed structural actuators. This arrangement will supply the highest available volume flow to the structural actuators for their demanding applications for real time hybrid and other high-demand testing. Also available are three low flow distribution manifolds along the south edge of the floor that are evenly spaced and each is provided with two sets of hand and check valves on the testing floor level.

2.2. Support areas

2.2.1. Fabrication area

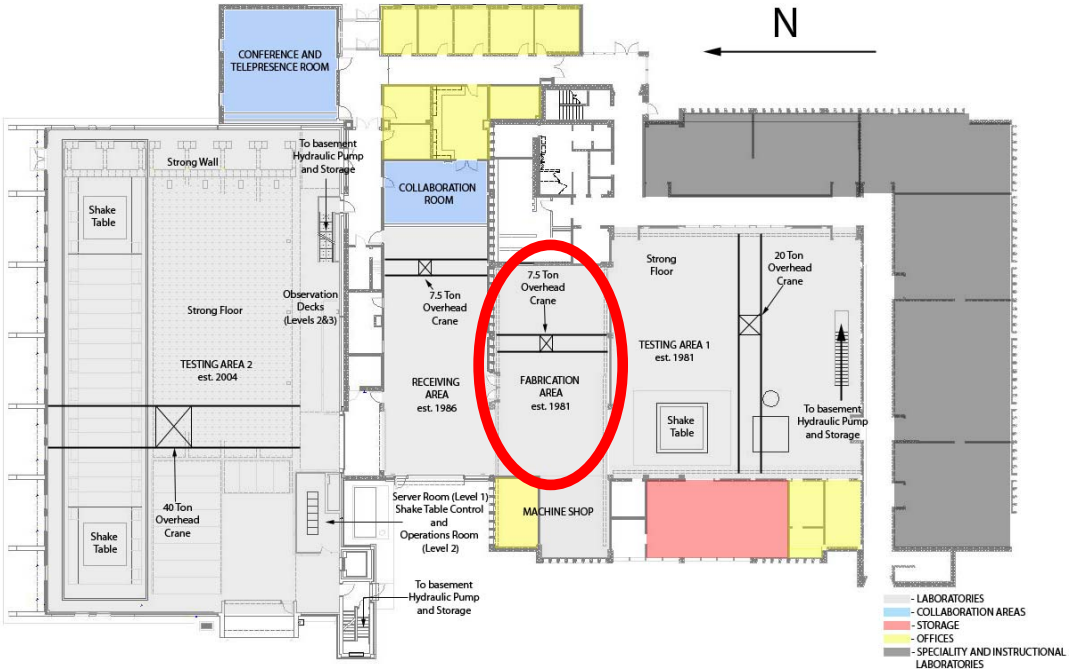


Figure 2.2.1-1: Fabrication area within Plan of Laboratory Facilities

The Fabrication Area is located between Testing Areas 1 and 2. The area is approximately 58 ft. (17.7m) long and 31 ft. (9.5m) wide, and has direct access to the delivery area and loading bay. Moreover, the area features an additional enclosed 19 ft. by 22 ft. (5.8m by 6.7m) restricted machine area and a 12 ft. by 20 ft. (3.7m by 6.1m) technician's office. The area has a 15 kip (66kN) capacity overhead bridge crane that is capable of moving materials and test units within the fabrication area. A 6 kip (27kN) capacity forklift is available and typically stored in the Fabrication or Delivery Areas.

A Tinius Olsen Universal Testing Machine is located within the Fabrication Area. A MTS 150 kip (667kN) Compression/Tension Machine is located in this area as well. These machines are used in the testing of concrete specimens, in the calibration of load cells and in the compression testing of elastomeric and sliding bearings.

2.2.1.1. Machine shop area

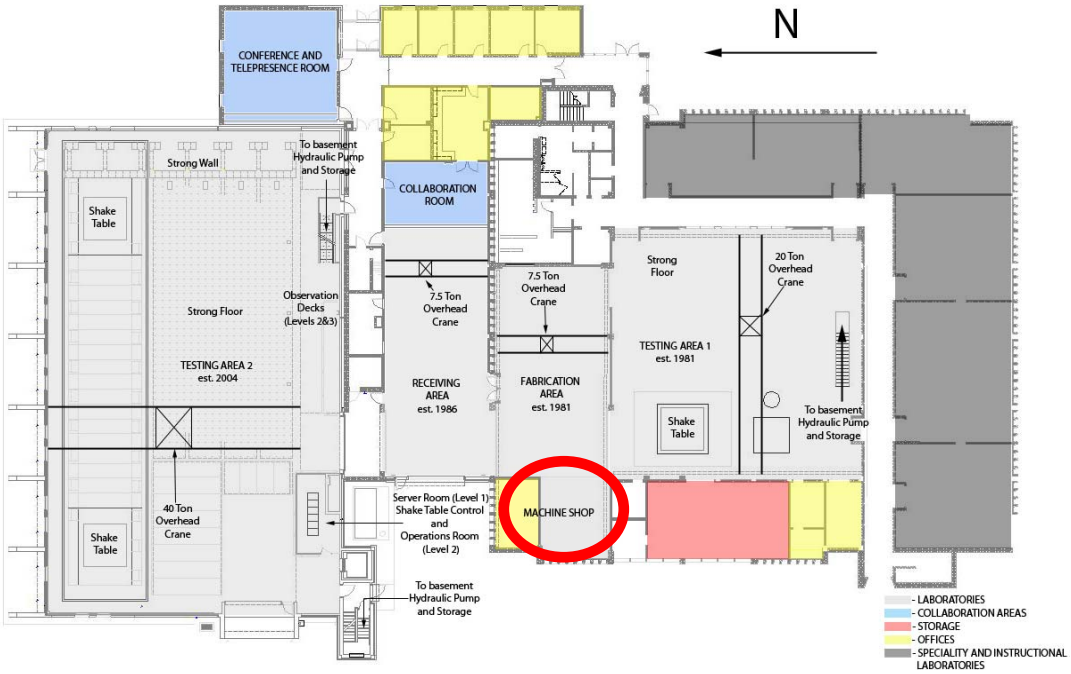


Figure 2.2.1.1-1: Machine Shop area within the Plan of Laboratory Facilities

The laboratory maintains facilities and personnel for performing machining, fabrication, welding and erection of structural systems. The equipment necessary to do so is located and stored within the Fabrication Area. Available equipment includes the following:

- Large Drill Press
- Small Drill Press
- Lathe Machine
- Small Lathe Machine
- Vertical Saw
- Horizontal Saw
- Surface Grinder
- Bench Grinder
- Mill Machine
- Mig Welder
- Tack Welder
- Stick Welder
- Pipe Threading Machine
- Inspection Table

Figure 2.2.1.1-2: View of Machine Shop

2.2.1.2. Welding facility

SEESL is equipped with several welding stations that can be moved to anywhere within the lab. The welding machines available are:

- Mig Welder
- Tack Welder
- Stick Welder

Figure 2.2.1.2-1: Welding Station

2.2.1.3. Materials storage

Figure 2.2.1.3-1: View of Materials storage

2.2.1.4. Gantry crane

Machine shop area has a 15 kip (66kN) capacity overhead bridge crane that is capable of moving materials and test units within the area

Figure 2.2.1.4-1: View of the Fabrication Area and the Gantry crane

2.2.2. Delivery area

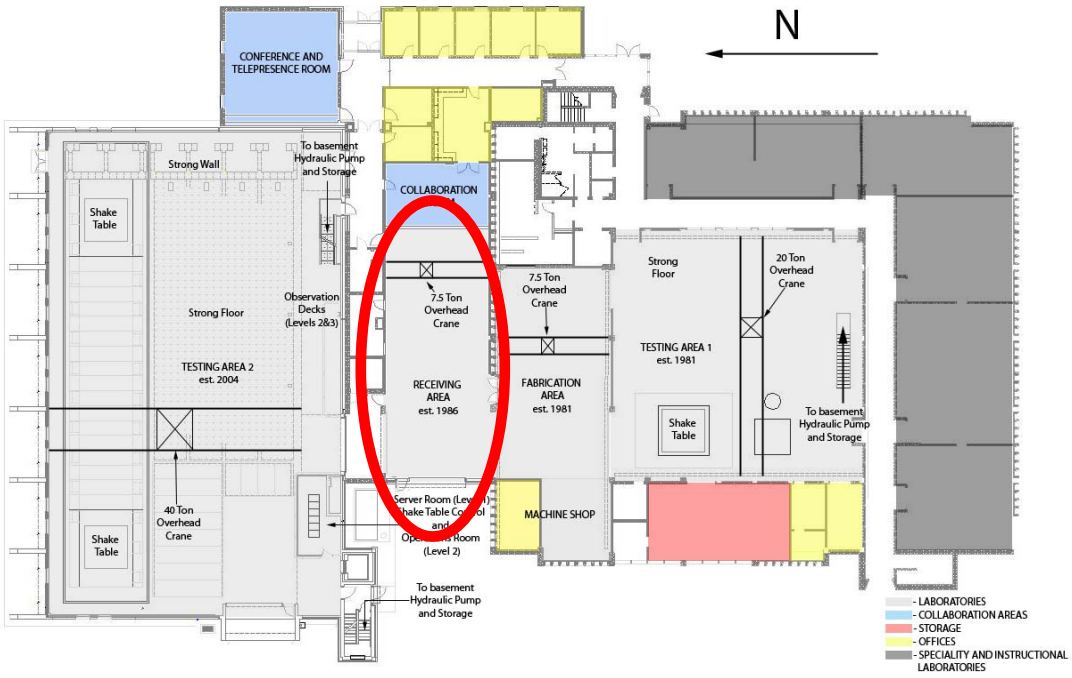


Figure 2.2.2-1: Delivery Area within Plan of Laboratory Facilities

The Delivery Area is located between Testing Area 2 and the Fabrication Area. The area is approximately 58 ft. (17.7m) long and 28 ft. (8.5m) wide, and has direct access to the loading bay. The area has a 15 kip (66kN) capacity overhead bridge crane that is capable of moving materials and test units within the Delivery Area. Access to the loading bay is through an overhead door with 15ft.-4 in. 4.7m) width and 16 ft.-8 in. (5.1m) height.

The back of the Delivery Area features a carpenter's shop that is used in both the fabrication of specimens and in the fabrication of furniture used in the Department of Civil, Structural and Environmental Engineering.

Figure 2.2.2-2: View of the Delivery Area

2.2.2.1. Rigging equipment

List of the available rigging equipment :

- 6 kip (27kN) capacity forklift
- 2 ton capacity Strong Bac
- 0.45 ton (1000 lbs) capacity Crane Basket

Figure 2.2.2.1-1: Forklift

Figure 2.2.2.1-2: Strong Bac

Figure 2.2.2.1-3: Crane Basket

2.2.2.2. Personnel Platforms

Two Electric Scissor lifts are available for lifting personnel within all the lab areas

Figure 2.2.2.2-1: Electric Scissor Lifts

2.2.2.3. Gantry crane

Delivery area is equipped with 15 kip (66kN) capacity overhead bridge crane that is capable of moving materials and test units within area.

Figure 2.2.2.3-1: View of the 15kip Gantry Crane

2.2.3. Wood fabrication area

Wood fabrication area is equipped with following:

- Table Saw
- Panel Saw
- Circular Saw
- Air Extractor

Figure 2.2.3-1: Wood Fabrication Area

2.3. Related Support facilities

2.3.1. Soil testing lab

The geo-engineering research laboratory includes (a) two automated computer controlled (Geocomp and GDS) apparatus for stress/strain controlled static/cyclic triaxial testing, consolidation and permeability testing, (b) two (Brainard-Kilman) pressure panels capable up to 1400kPa of pressure, (c) 70 mm diameter triaxial cells and flexiwall permeameters, (d) two Geotest (S22/5A) 100x100mm direct shear test apparatus and one 100x100mm Soil Test (D-500A) direct shear apparatus and digital data acquisition system, (e) Five 70mm diameter ELE consolidation cells and load stations with 8-channel ELE digital data logger, (f) two HP network analyzers (LF Impedance Analyzer 4192A, 5Hz-13MHz and RF Impedance/Material Analyzer 4191A, 1MHz-1.8GHz) for material characterization/non-destructive testing; (g) a 60 cm diameter and 2.25m high calibration chamber and model test facility for static and dynamic penetration testing and model pile studies. The laboratory is provided with compressed air up to 700kPa pressure.

Geocomp apparatus consists of Loadtrac, Flow Trac, Hydraulic loading frame, Parker Actuator, Triaxial cells, signal conditioning unit, and Pentium-III computer and software for triaxial shear, cyclic shear, permeability, and consolidation testing. Specimens up to about 70 mm diameter with a cell pressure up to 800kPa can be tested. Axial load capacity is 2000 lbs. Axial strain up to 25% can be reached. Cyclic loading frequency in the range of 0.1 to 10Hz is possible.

GDS apparatus consists of digital panels for back pressure saturation, cell and pore pressure control, and loading and a computer. Specimen size is limited to 38 mm. Axial strain up to 25% can be reached. Cyclic loading frequency is limited to 2Hz.

The geo-engineering laboratory also includes a laminar box (2.75(W)x5(L), 6.2m high, internal dimensions) for full-scale prototype 1-g soil and soil-structure interaction studies for earthquake engineering research as described in the NEES Laboratory Manual.

2.3.2. Instructional soil lab

The laboratory is equipped for conducting standard laboratory tests including classification tests, compaction, permeability (constant head and falling head), unconfined compression and direct shear tests.

In particular the laboratory houses (a) two Geotest (S22/5A) 100x100mm direct shear test apparatus and one 100x100mm Soil Test (D-500A) direct shear apparatus and digital data acquisition system, (b) five 70mm diameter ELE consolidation cells and load stations with 8-channel ELE digital data logger, and (c) two Geotest (S 2013 and S 2014) unconfined compression test machines.

While the laboratory is used primarily for undergraduate instruction, it is also used for research.

2.3.3. Instructional structures lab

The laboratory houses an MTS Axial-Torsion machine (shown in Figure 2.3.3-1), a small portable shake table, several frames for loading small structural models, a small electro-hydraulic actuator, four computers and a portable data acquisition system.

The MTS machine is capable of applying 100 kips (445kN) tension, 50 kip-in. (5.65kN-m) torque and rotation of up to 50 degrees. It is used both for instruction and research.

The small portable shake table is used for instruction and demonstrations in the laboratory and in classrooms. It is often transported to local schools and museums for demonstrations. It is equipped with two scaled models of a seismically isolated structure and of a damped structure; both built using a length scale of 16 and a time scale of 4.

The portable data acquisition system features 16 channels of data acquisition and LabView data acquisition software.

Figure 2.3.3-1: Picture of MTS Axial-Torsion machine

2.3.4. Electronics Packaging Laboratory

Electronic Packaging Laboratory is a multi-disciplinary research laboratory in the Department of Civil, Structural and Environmental engineering. It brings together faculty members from civil, electrical, mechanical and chemical engineering for interdisciplinary research. The focus of the laboratory is the development of next generation microelectronics technology as well as finding new applications for their use in real world, such as using MEMS sensors for earthquake instrumentation and chemical agent detection in and around civil infrastructure.

The laboratory has extensive material characterization facilities, including a thermal chamber, high g (300g) vibration system, and material characterization units for mechanical, electrical, optical and thermal property determination. The laboratory also houses a sophisticated Moire interferometry system. More information about the laboratory can be found at the website www.packaging.buffalo.edu

Figure 2.3.4-1 Electronics Packaging Laboratory

Figure 2.3.4-2 Electronics Packaging Laboratory

3. Laboratory Equipment

3.1. Shake Tables

Shake table A and B – 6 DOF

Key elements of the SEESL are the two movable, six degrees-of-freedom, shake tables, which can be rapidly repositioned from directly adjacent to one another to positions up to 100 feet apart. Together, these tables can host specimens of up to 100 metric tons and as long as 120 feet, and subject them to fully in-phase or totally uncorrelated dynamic excitations.

Figure 3.1-1: Shake Table A with Instrumentation Frame and specimen (w/o table extension)

Figure 3.1-2: Shake Table B (w/o table extension)

3.1.1.1. Physical data of Shake Tables

Each shake table has plan dimensions of 3.6 x 3.6 meter and is made of a welded steel construction with a weight of approximately 8 tons. Each table has a painted top surface.

A Parking Frame System consisting of a welded steel frame with electric actuators raises each table for repositioning within the length of the trench. The carrier capable of raising the table with the (4) horizontal actuators, (2) actuator buttresses, and (4) vertical actuators is attached. A steel beam is used for securing the horizontal actuator buttresses to the table during movement. The carrier rides on polyurethane wheels for ease of positioning and tracks along a center rail embedded in the trench floor being moved with a winch system.

Each shake table is driven by the following hydraulic actuators:

1. Longitudinal (X and Y-axis) hydraulic actuators (quantity = 2 each axis)

MTS Model 244.4 Hydraulic Actuator with a dynamic force rating of 21 metric ton and a dynamic stroke of 300 mm (±150 mm). The actuator assembly includes the following:

a. Hollow single piece rod
b. Model 256.25S servovalve rated at 1000lpm
c. LVDT type stroke transducers
d. Swivel heads and bases
e. Close-coupled pressure and return accumulators
f. Differential pressure cells.

2. Vertical (Z-axis) hydraulic actuator (quantity =4)

MTS Model 206.S Hydraulic Actuator with a dynamic force rating of 25 metric ton and a dynamic stroke of 150 mm (±75 mm). The actuator assembly includes the following:

a. Hollow single piece rod
b. Model 256.18s servovalve rated at 650lpm
c. LVDT type stroke transducers
d. Swivel heads and bases
e. Close-coupled pressure and return accumulators
f. Differential pressure cells

g. Integral static support with 20 ton capacity (total static support capacity is 20 ton x 4 = 80 ton) will all necessary nitrogen supply and control system.

The Hydraulic Power Supply (HPS) subsystem for both shake tables consists of four MTS Model 506.92 pumps rated at 185gpm (700lpm) at 3,000psi (207 bar) each.

3.1.1.2. Tables Extensions

There are the two 7 x 7 meter shake table extension platforms available for each of the shake tables. The Platforms are of welded steel construction with a weight of approximately 9.8 tons. The extensions have painted top surface.

Figure 3.1.1.2-1: View of both shake tables with extension platforms in place

Figure 3.1.1.2-2: Shake Table B with extension platform

3.1.1.3. Performance Data

The two six degrees-of-freedom shake tables are designed for the nominal performance shown in Table 1. These performance data are based continuous uniaxial sinusoidal motion with 20-ton rigid specimen. System performance levels will be reduced with payloads larger than nominal.

Table 1: Performance data of six degrees-of-freedom shake tables.

Table size w/o table extension:	3. 6 meter x 3.6 meter
Table size w/ extension platform in place:	7 meter x 7 meter
Maximum specimen mass:	50 ton maximum / 20 ton nominal
Maximum specimen mass with table extension platform in place:	40 ton maximum
Maximum Overturning Moment:	46 ton meter
Maximum Off Center Loading moment:	15 ton meter
Frequency of operation:	0.1~50 Hz nominal/100 Hz maximum
Nominal Performance:	X axis Y axis Z axis
Stroke:	±0.150m ±0.150m ±0.075m
Velocity:	1250 mm/sec 1250 mm/sec 500 mm/sec
Acceleration:	±1.15 g ±1.15 g ±1.15 g (w/20 ton specimen)

3.1.1.4. Drawings

Figures 1 to 5 present construction drawings for the six degrees-of-freedom shake tables. Figure 1 presents general plan view of the laboratory floor including the two shake tables in the trench next to a reaction wall. Figure 2, 3 and 4 shows top, bottom, and side views of one of the shake tables, respectively. Figure 5 shows details of the mounting bolts used to anchor a test specimen on the shake tables.

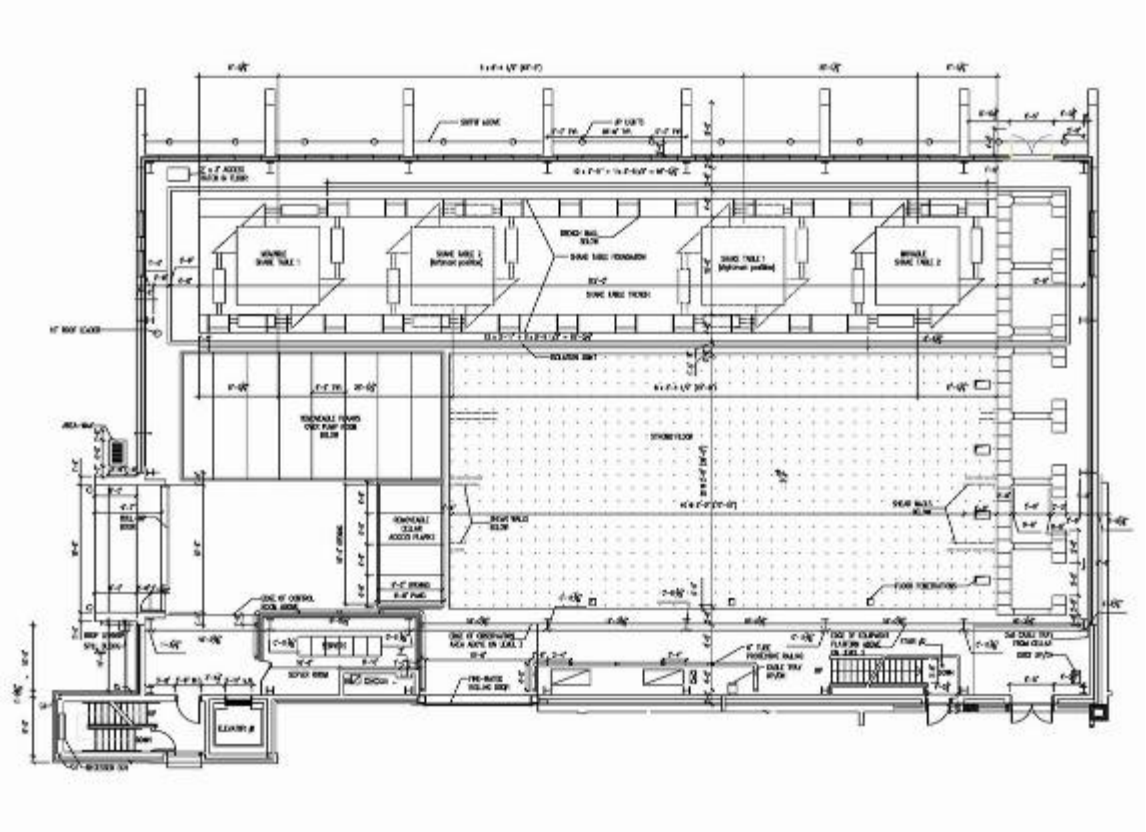


Figure 3.1.1.4-1: General plan view of laboratory floor

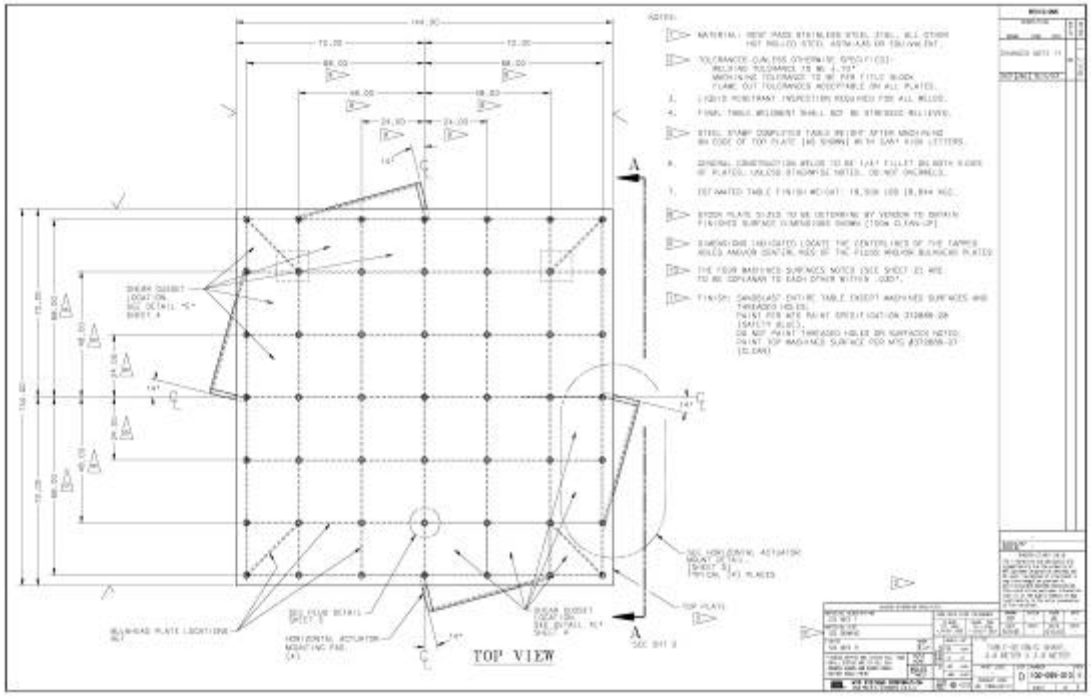


Figure 3.1.1.4-2: Top view of six degrees-of-freedom shake tables

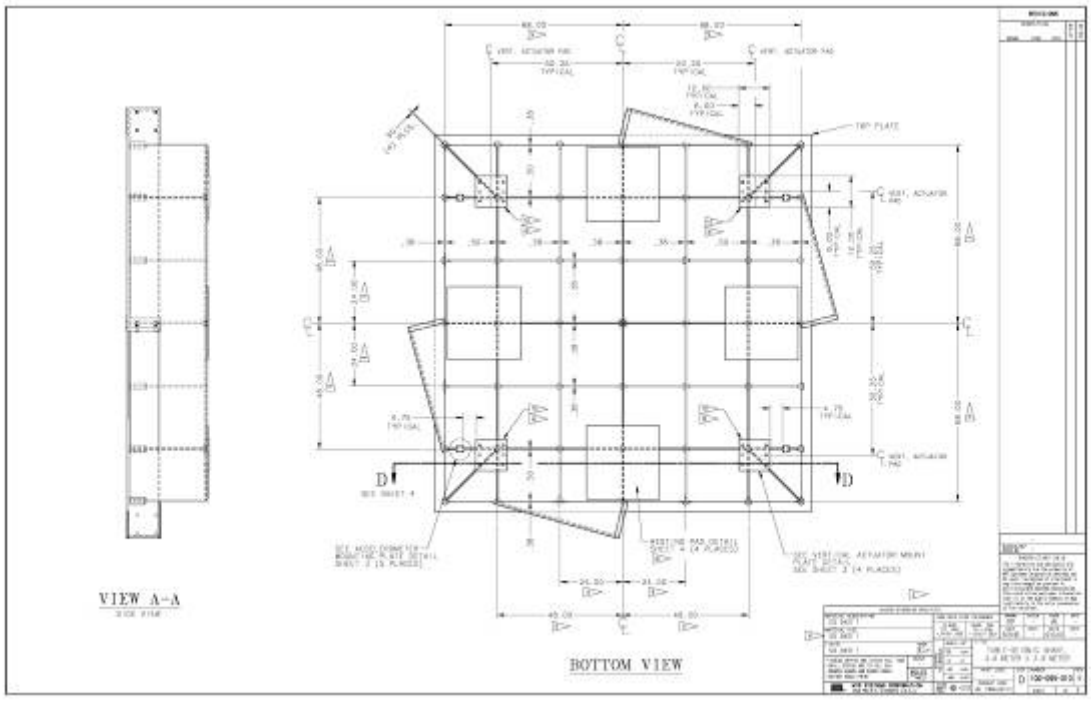


Figure 3.1.1.4-3: Bottom view of six degrees-of-freedom shake tables

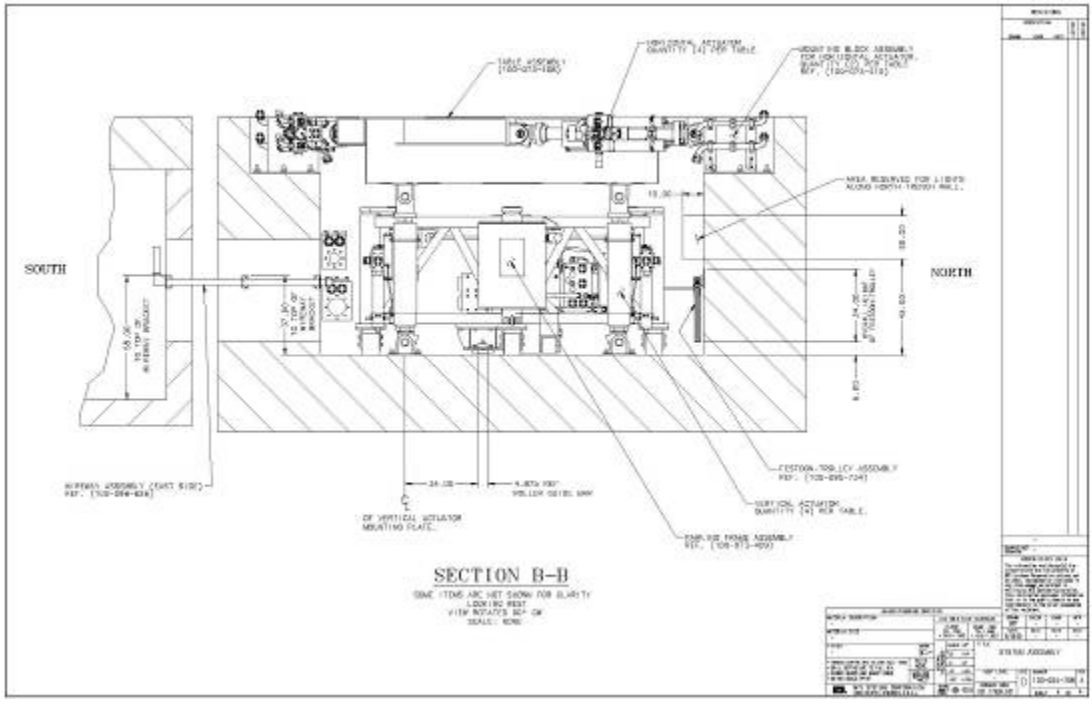


Figure 3.1.1.4-4: Side view of six degrees-of-freedom shake tables

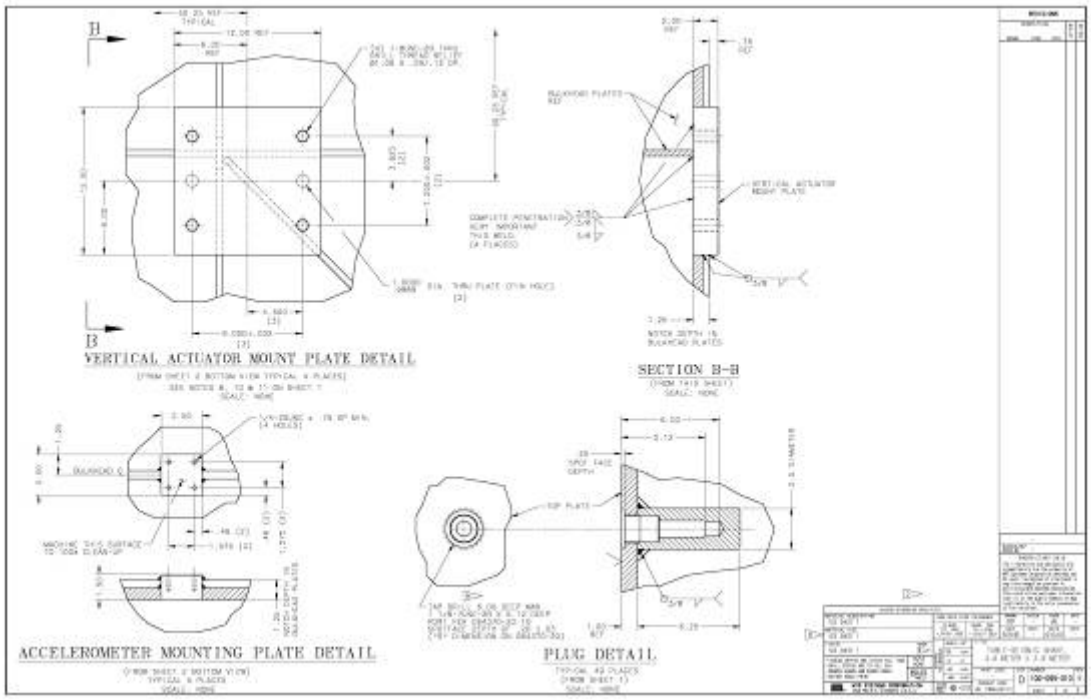


Figure 3.1.1.4-5: Mounting bolts details of six degrees-of-freedom shake tables

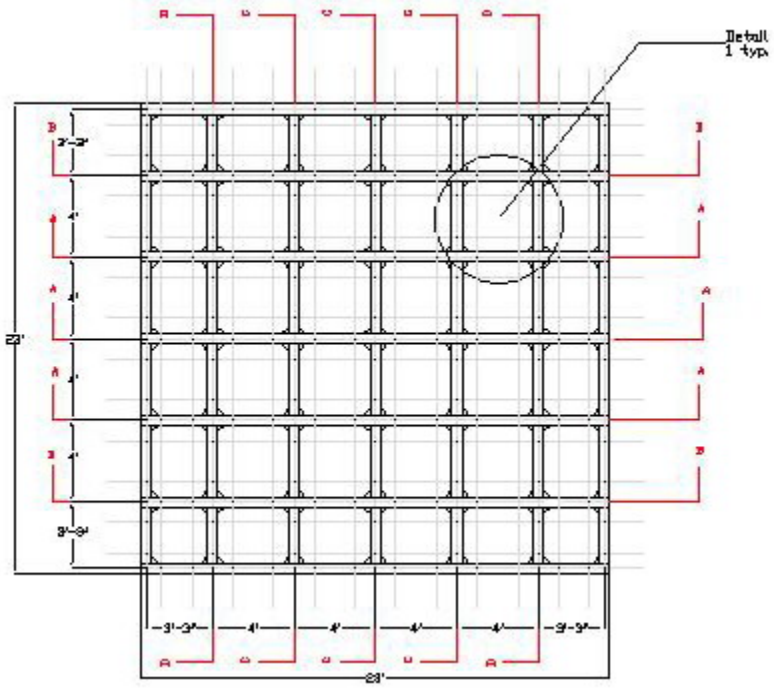


Figure 3.1.1.4-6: Plan view of table extension

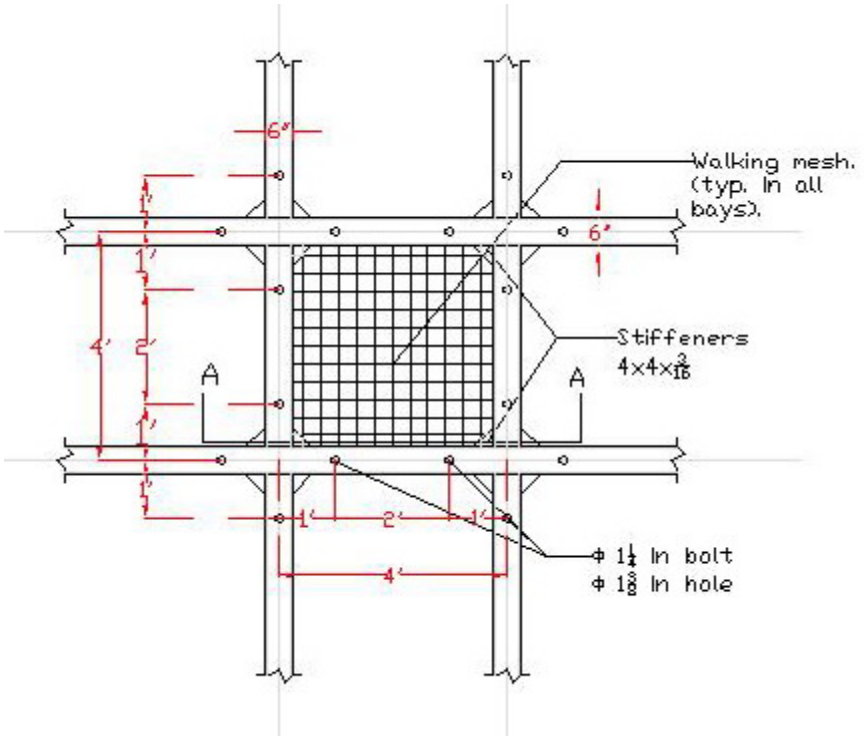


Figure 3.1.1.4-7: Plan view of table extension, Detail 1

3.1.2. Shake table O – 6 dof

Located in the original SEESL, the 3.66 by 3.66 m shake table has six controlled degrees of freedom (excluding the transverse translational movement). The longitudinal (horizontal), vertical and roll degrees of freedom are programmable with feedback control to simultaneously control displacement, velocity, and acceleration.

3.1.2.1. Physical data

The five degree-of-freedom shake table has payload capacity of 50 tons and a useful frequency range of 0 to 50 Hz. The table is normally furnished with a reinforced concrete testing platform of 6.1 m by 3.66 m plan dimensions that extends the useful testing area beyond the table's dimensions but limits the payload to 42.5 tons. The testing platform has holes on a one foot square grid for attaching test specimens.

3.1.2.2. Capacity data

The five degrees-of-freedom shake table is designed for the nominal performance shown in Table 2. These performance data are based continuous uniaxial sinusoidal motion with 20-ton rigid specimen. System performance levels will be reduced with payloads larger than nominal.

Table 2 : Performance data of five degrees-of-freedom shake tables

Table size:	3. 66 meter x 3.66 meter
Maximum specimen mass:	50 ton maximum / 20 ton nominal

Maximum Overturning Moment:	46 ton meter
Maximum Off Center Loading moment:	15 ton meter
Frequency of operation:	0.1~50 Hz
Nominal Performance:	X axis Z axis
Stroke:	±0.150m ±0.075m
Velocity:	762 mm/sec 500 mm/sec
Acceleration:	±1.15 g ±2.30 g (w/20 ton specimen)

3.1.2.3. Drawings

Figure 3.1.2.3-1 represents a perspective view of the five degrees-of-freedom shake table and foundation Figure 3.1.2.3-2 presents a top view of the testing platform of the five degrees-of-freedom shake table. Figure 3.1.2.3-3 presents a photograph of the five degrees-of-freedom shake table with a test specimen installed on it.

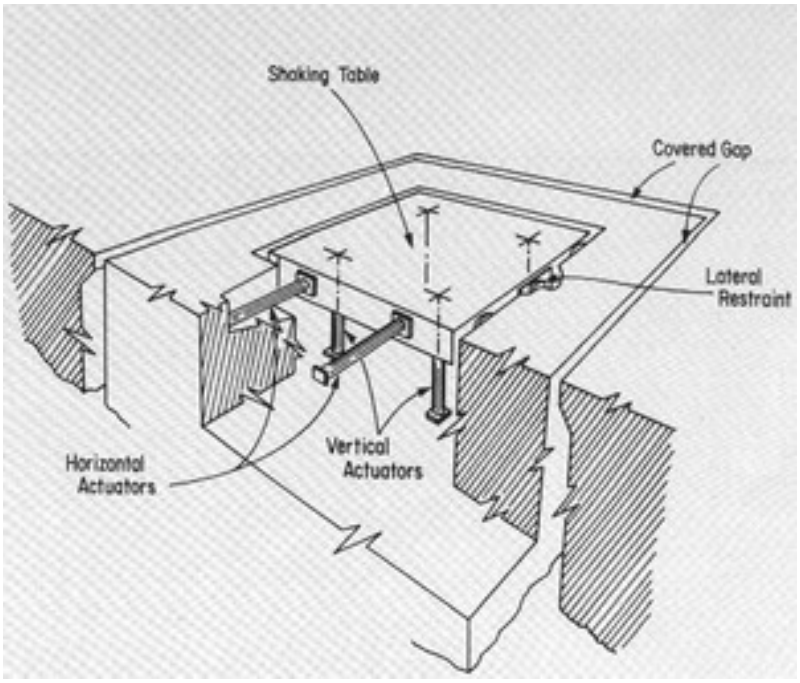


Figure 3.1.2.3-1: Five degrees-of-freedom shake table and foundation

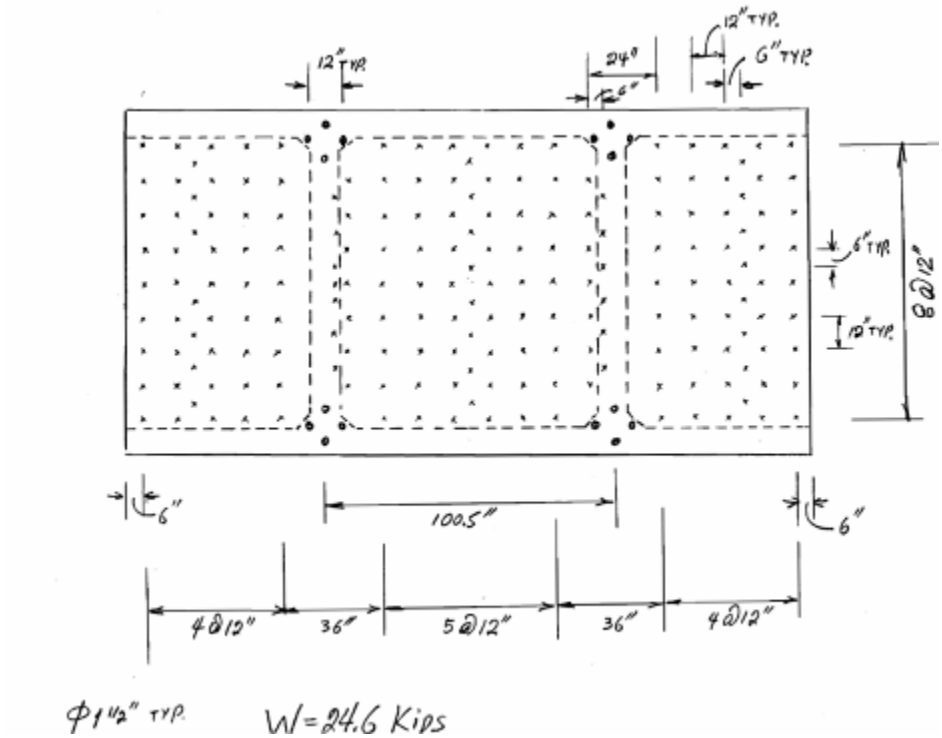


Figure 3.1.2.3-2: Top view of testing platform of five degrees-of-freedom shake table

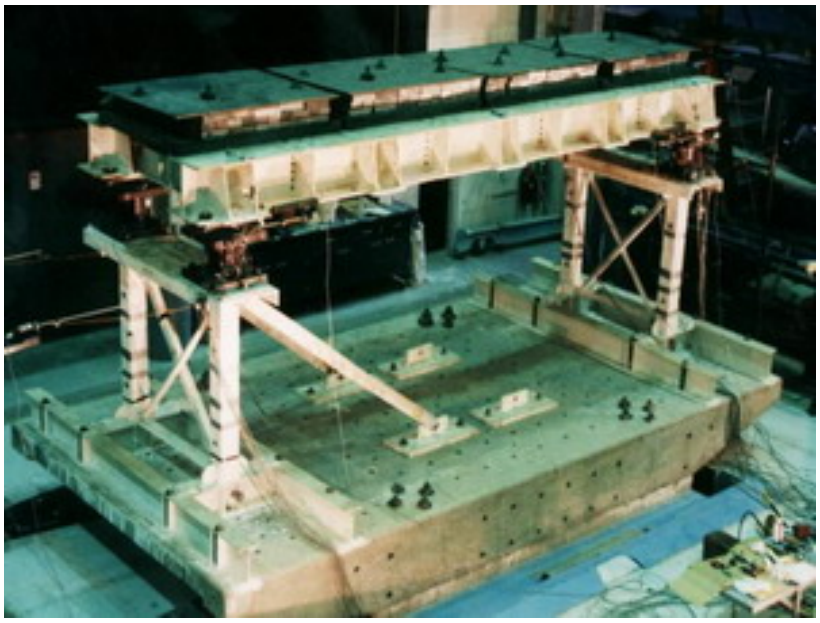


Figure 3.1.2.3-3: Photograph of five degrees-of-freedom shake table with specimen

3.1.3. Single degree-of-freedom shake table

The SEESL also hosts a smaller (0.91m x 1.52m) single degree-of-freedom (horizontal) shake table that has a payload capacity of at least 3 tons. The specimen height for the single degree-of-freedom shake table is restricted by uplift conditions since the table rides on slide bearings. The single degree-of-freedom shake table is suitable for use with an available three-story, 3 tons steel model structure.

3.1.3.1. Physical data

The single degree-of-freedom shake table is driven by a 25kN actuator equipped with two 15gpm (56.78lpm) servovalves.

3.1.3.2. Capacity data

The single degree-of-freedom shake table is designed for the nominal performance shown in Table 3. These performance data are based continuous uniaxial sinusoidal motion with a 3 ton rigid specimen. System performance levels will be reduced with payloads larger than nominal.

Table 3: Performance data of single degree-of-freedom shake tables

Table size:	0. 91 meter x 1.52 meter
Maximum specimen mass:	3 ton nominal
Maximum Overturning Moment:	Limited by bearing capacity
Maximum Off Center Loading moment:	Unknown
Frequency of operation:	0.1~50 Hz
Nominal Performance:	X axis
Stroke:	±0.762m
Velocity:	762 mm/sec
Acceleration:	±0.80 g (w/3 ton specimen)

3.1.3.3. Drawings

Figure 3.1.3.3-1: Photograph of single degree-of-freedom shake table with dedicated 3-ton specimen

3.2. REACTION WALLS

3.2.1. Reaction Wall –Test Area 2

Reaction Walls and Strong Floors allow 2 for testing of structual components such as steel trusses and concrete slabs.

3.2.1.1. Physical data

Reaction Wall next to Strong Floor:

- Length: 41'-0"
- Height: 30'-0''
- Thickness: 2'-0"

Reaction Wall next to Shake Table Trench:

- Length: 23'-0"
- Height: 30'-0"
- Thickness: 2'-0"

3.2.1.2. Capacity data

Table 4: Strong Wall Capacity Data

Allowable load per strip along **NUMBERED lines (based on shear)**							
Position	Lines	Max force				shear strength	clear span
ft		kip/ft	kN/ft	kN/m	ton/m	ton/m	ft
1		120	544	1784	182	172	9.00
3		157	712	2333	238	172	9.00
5		226	1028	3370	343	172	9.00
Allowable concentrated load PER HOLE (based on shear strength)							
Position		Max force				shear strength	clear span
ft		kip	kN	kN	ton	ton/m	ft
1		239	1088	1088	111	172	9.00
3		313	1423	1423	145	172	9.00
5		452	2055	2055	210	172	9.00
Allowable concentrated load PER HOLE (based on moments)							
Position			hole @	2 ft	0.61m		gross span
ft		kip	kN	kN	ton	ton-m/m	ft
1		241	1096	1096	112	165	10.00
3		103	470	470	48	165	10.00
5		87	395	395	40	165	10.00
Allowable concentrated load PER HOLE (based on punching shear)							
Position		Max force				shear strength	clear span
ft		kip	kN	kN	ton	kips	ft
1		182	826	826	84	182	10.00
Allowable moment per strip along **ALPHABETICAL** lines **(based on shear)**							
Position							gross span
		kip-in/ft	kip-ft/ft	kN-m/ft	ton-m/m	ton-m/m	ft
		4352	363	493	165	165	10.00
Allowable overturning moment per vertical strip							
Position							gross span
		kip-in/ft	kip-ft/ft	kN-m/ft	ton-m/m	ton-m/m	ft
		13056	1088	1480	495	495	10.00
Allowable position for actuators							
Size			Height from the floor			Mom.strip of holes	gross span
ton			in	ft	m	ton-m/m	ft
50			324	27.0	8.24	302	10.00
100			237	19.8	6.03	302	10.00
200			119	9.9	3.02	302	10.00
YELLOW FORCES GOVERN THE DESIGN							

3.2.1.3. Drawings

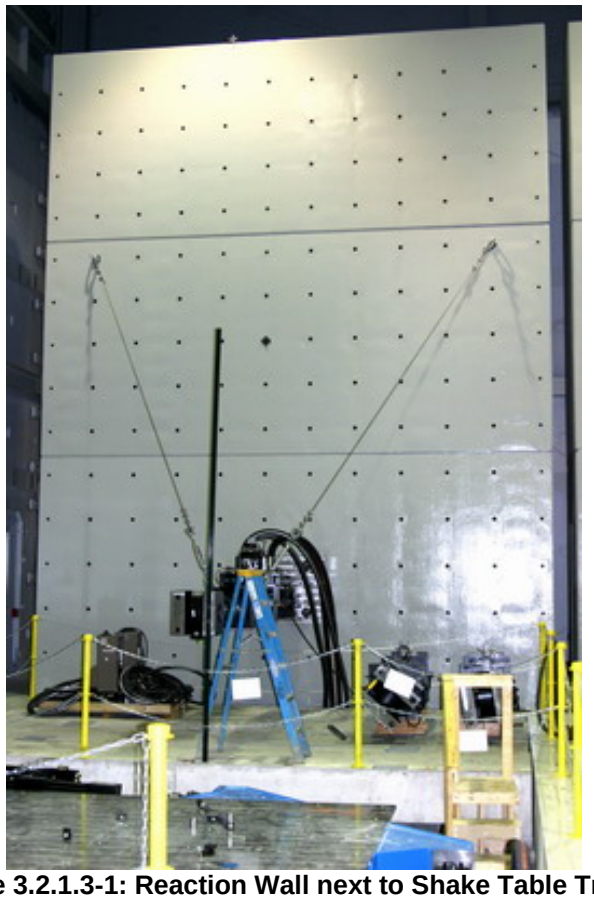


Figure 3.2.1.3-1: Reaction Wall next to Shake Table Trench

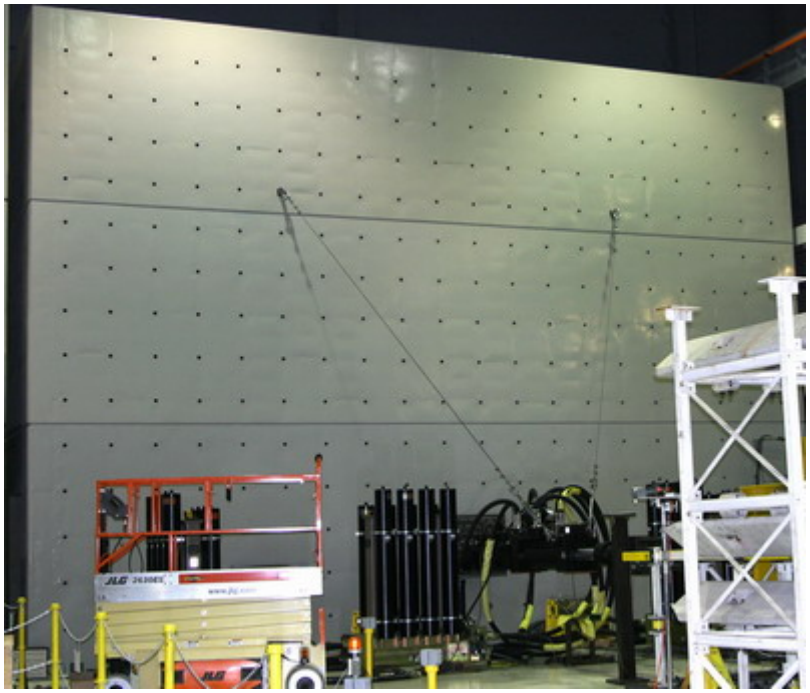


Figure 3.2.1.3-2: Reaction Wall next to Shake Table Trench

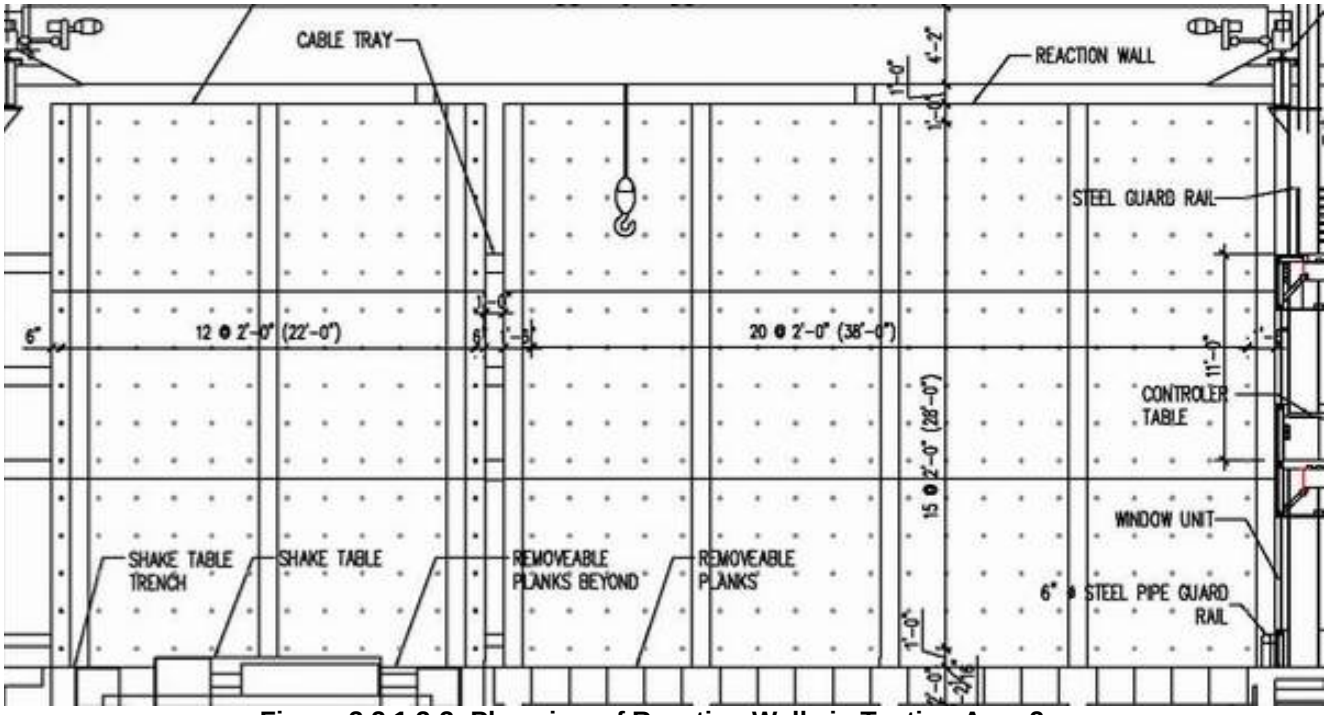


Figure 3.2.1.3-3: Plan view of Reaction Walls in Testing Area 2

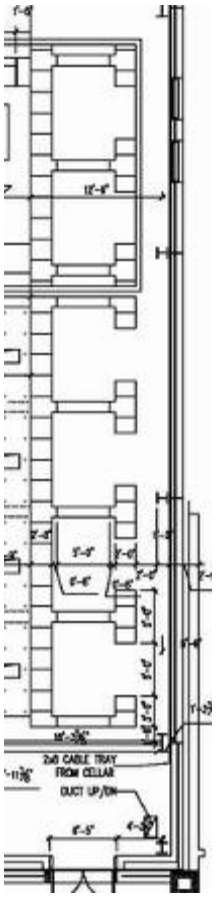


Figure 3.2.1.3-4: Cross-section of Reaction Walls in Testing Area 2

3.3. Strong Floors

3.3.1. Strong Floor O – Test Area 1

3.3.1.1. Physical data

The test floor is a five cell reinforced concrete box girder 40 ft. (12.2m) long, 60 ft. (18.3m) wide, and 8 ft. (2.5m) overall in height. The thickness of the top test floor slab is 18 in. (46 cm). Tie down points consist of (4) 2 ½" holes which are arranged symmetrically in both directions.

3.3.1.2. Capacity data

Each tie down point has an axial load allowable capacity of 250 kips (1112kN). Figure 2 presents a view of the strong floor including the layout of the tie down points.

3.3.1.3. Drawings

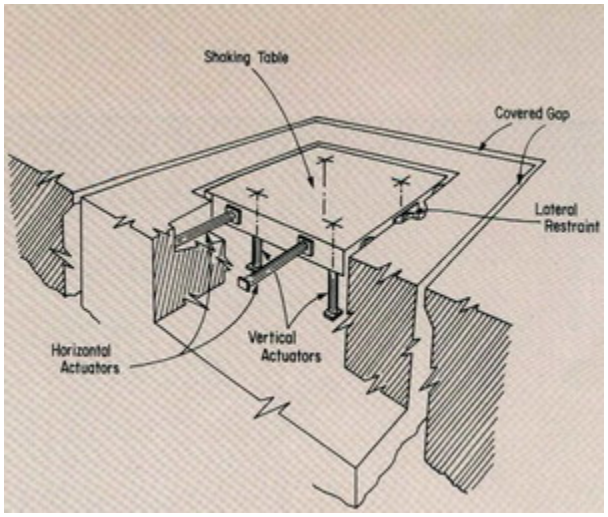


Figure 3.3.1.3-1: Strong Floor in Testing Area 1

3.3.1.4. Simulation Drawings

3.3.2. Strong Floor – Test Area 2

3.3.2.1. Physical data

The test floor is a reinforced concrete box girder 79 ft. (24m) long, 39 ft. (11.8 m) wide. The thickness of the top test floor slab is 24 in. (60 cm).

3.3.2.2. Capacity data

Table 5: Strong Floor Capacity Data

Allowable load per strip along **NUMBERED lines** (based on shear)							
Position	Lines	Max force				shear strength	clear span
ft		kip/ft	kN/ft	kN/m	ton/m	ton/m	ft
1		120	544	1784	182	172	9.00
3		157	712	2333	238	172	9.00
5		226	1028	3370	343	172	9.00
Allowable load per strip along **NUMBERED lines** (based on moment)							
Position		Max force					clear span
ft		kip/ft	kN/ft	kN/m	ton/m	ton/m	ft
1		89	407	1333	136	122	9.00
3		38	174	571	58	122	9.00
5		32	146	480	49	122	9.00
Allowable concentrated load PER HOLE (based on shear strength)							
Position		Max force				shear strength	clear span
ft		kip	kN	kN	ton	ton/m	ft
1		239	1088	1088	111	172	9.00
3		313	1423	1423	145	172	9.00
5		452	2055	2055	210	172	9.00
Allowable concentrated load PER HOLE (based on punching shear)							
Position		Max force					gross span
ft		kip	kN	kN	ton	kips	ft
1		182	826	826	84	182	10.00
Allowable concentrated load PER HOLE (based on moment)							
Position		Max force				moment strength	gross span
ft		kip	kN	kN	ton	ton-m/m	ft
1		179	813	813	83	122	10.00
3		77	349	349	36	122	10.00
5		64	293	293	30	122	10.00
Allowable moment per strip due to load along ALPHABETICAL lines							
Position		Max force					gross span
		kip-in/ft	kip-ft/ft	kN-m/ft	ton-m/m	ton-m/m	ft
		3229	269	366	122	122	10.00
YELLOW FORCES GOVERN THE DESIGN							

3.3.2.3. Drawings

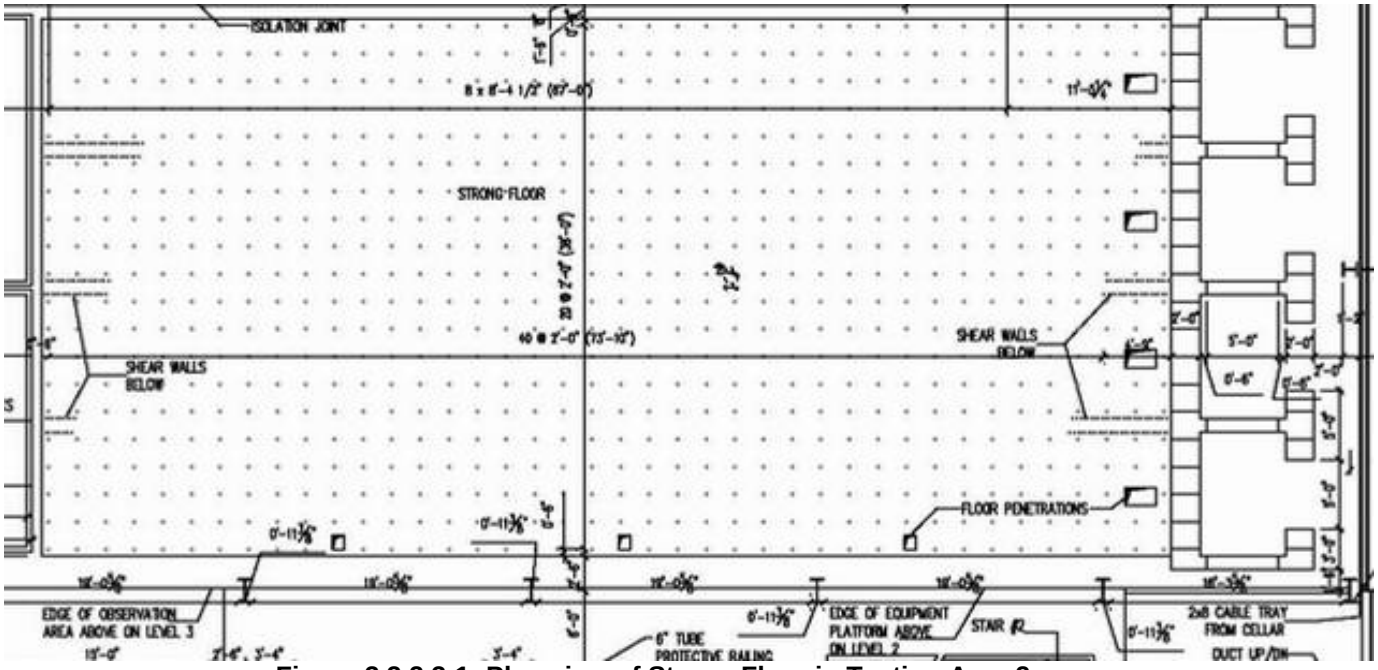


Figure 3.3.2.3-1: Plan view of Strong Floor in Testing Area 2

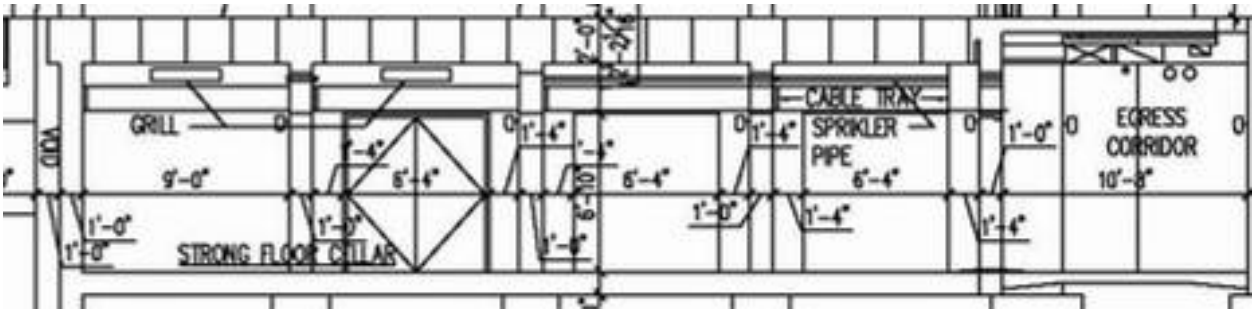


Figure 3.3.2.3-2: Cross-section view of Strong Floor in Testing Area 2

3.4. Hydraulic Power Supply Systems

3.4.1. Test Area 1

Table 6: Flow Rate Data of HPS in Testing Area 1

Device Type	Quantity	Flow Rate (per unit) gpm [lpm]	Equipment Designation
MTS506.81 HPS	2	140* [1245.5]	Non-NEES
MTS Manifold 290 Series	3	50 [189]	Non-NEES
MTS Manifold 290 Series	2	100 [378.54]	Non-NEES

Device Type	Quantity	Flow Rate (per unit) gpm [lpm]	Equipment Designation
MTS Manifold 290 Series	1	250[946.35]	Non-NEES

* Flow Rate available in increments of 70 gpm (265 lpm)

3.4.2. Test Area 2

3.4.2.1. Layout

The pump room, located in the basement of the Ketter Hall NEES lab addition, houses four MTS 506.92 Hydraulic Power Supply (HPS) units, each rated at 185gpm (700lpm) flow with 3,000psi (207 bar) working pressure. Each HPS consists of two high-pressure, variable volume main pumps and a low pressure “supercharge” pump that draws oil from the reservoir and supplies a constant oil pressure and flow to the inlets of the main pumps. These units have oversized reservoirs to accommodate the additional accumulator oil volume required for high performance dynamic testing. Hydraulic system oil is cooled by pumping hydraulic fluid through a system of heat exchangers (one located on each HPS) that are connected to the campus chilled water system. The chilled water is supplied at an average year-round temperature of 50 deg. F. Temperature-sensitive flow control valves are provided by MTS as part of the HPS assembly. These valves regulate the flow of chilled water through the heat exchangers as a function of hydraulic fluid system temperature. The hydraulic fluid is maintained at an optimum working temperature of 100 – 110 deg F.

Figure 3.4.2.1-1: MTS 506.92 Hydraulic Power Supply

3.4.2.2. Pumps

The laboratory hydraulic distribution system is an integrated solution for the combined functions of seismic and structural testing. The system was designed to minimize system expenditure (by reducing the use of duplication) and to maximize performance and capabilities.

The pump room piping segment is connected to the outputs of the four HPS units and runs directly to the through an opening in the table trench wall. The diameter of the common piping in the HPS room area is 130 mm pressure and 220 mm return line with 2 inch drain lines. The reservoirs of the HPS units are connected together with large diameter piping to provide a common reservoir from which all 8 pumps on the 4 HPS units can draw oil.

The seismic piping system runs along the length of the shake table trench. This piping is sized to allow both the seismic table and structural actuators to run simultaneously for hybrid testing applications with table-mounted specimens coupled with the strong wall at the east end of the trench. Hydraulic outlets with manual valves are located along the trench for positioning of the movable tables, offering maximum flexibility. Outlets are also located along the strong wall for connecting the Hydraulic Service Manifolds for the high flow structural actuators. Flexible hoses are used to connect the table system and the structural actuators to the main hard line distribution outlets.

Four hydraulic outlet stations are located along the table trench for connection of hoses. Two stations are used to connect to the moveable tables at any one time and any free stations can be used to allow connection of structural actuators to the strong floor along the north side of the floor for certain configurations. By design, one trench distribution manifold station will allow one table to be positioned to any one of four locations without breaking hose connections. This helps simplify repositioning of the table system.

The main branch line running from the HPS piping manifold in the table trench area to the east end of the trench is sized to provide in excess of 1200 GPM pressure and 1600 GPM return (average) of oil flow using 150 mm pressure piping and 220 mm return piping with 2 inch drain lines. Wall openings are cast into the concrete structure of the basement and the table trench, through which the hard line is routed.

Over 700 gallons of oil volume accumulation (Figure 3.4.2.2-1) is provided through four distributed accumulation bank systems. These accumulators are located in the basement below the strong floor adjacent to the high flow hydraulic distribution manifolds (see figure x). These are engineered to operate in a horizontal manner to provide maximum accessibility for maintenance in the basement.

Figure 3.4.2.2-1 MTS Accumulator System (Qty: 4)

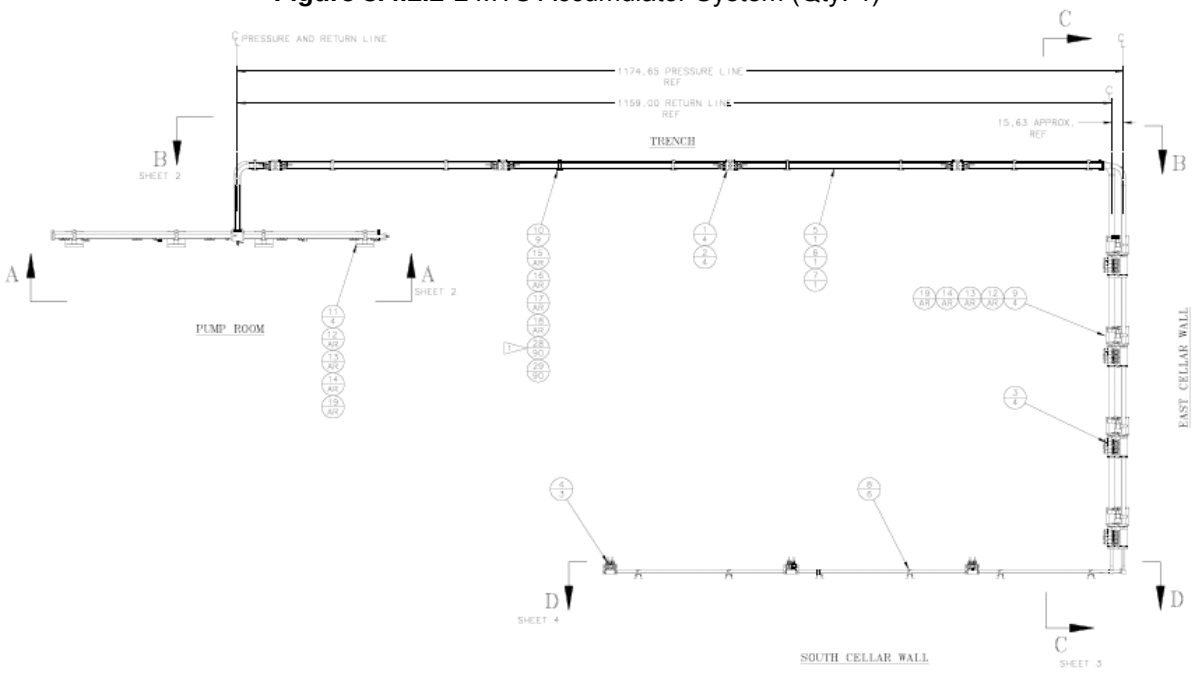


Figure 3.4.2.2-2 Hydraulic Distribution System

At the end run of the main branch line, a secondary piping distribution runs south below the strong floor along the strong wall to service the structural testing area. This secondary branch line for structural testing also consists of 150 mm pressure piping and 220 mm return line piping with 2 inch drain lines along the length of the strong wall. Line accumulation from the individual Hydraulic Service Manifolds and the basement accumulation banks supplements the flow above the 800 GPM output from the HPS units as needed. Vertical risers run from the basement level through the strong floor to the four distribution manifolds mentioned earlier. The pressure risers are 130 mm and the return risers 140 mm in diameter. Strong floor cut outs (precast in the floor) allow the passage of the piping system from the basement to the top of the strong floor.

At the strong floor surface, adjacent to the strong wall, four high flow manual distribution manifolds **(**Error! Reference source not found.**)** are located, with four sets of 2 inch hand and check valves to allow connection to the three moveable Hydraulic Service Manifolds. This arrangement will supply the highest available volume flow to the structural actuators for their demanding applications for real time hybrid and other high-demand testing. These high flow manual distribution manifolds can also be used as general purpose distribution manifolds to connect other actuators for more traditional structural testing applications (when the high flow structural actuators are not in use) adding setup flexibility along the strong wall area.

Figure 3.4.2.2-3: MTS High Flow Hydraulic Distribution Manifold

Beginning at the fourth high flow structural testing distribution manifold location, approximately 60 feet of 75 mm diameter piping runs below the strong floor along the south edge of the floor. Three low flow distribution manifolds **(**Error! Reference source not found.**)** are evenly spaced along this piping run and each is provided with two sets of hand and check valves on the testing floor level. The vertical risers consist of 2 inch SST piping (pressure and return) to each distribution manifold.

Figure 3.4.2.2-4: MTS Low Flow Hydraulic Distribution Manifold

When considered as a single system, the hard line runs and outlet stations in the table trench, and the hard line runs and manifolds along the strong wall and south strong floor allow hydraulic power to be distributed to three sides of the strong floor area. This distribution scheme allows hydraulic power coverage over the majority of the strong floor area.

3.4.2.3. Service manifolds (ports)

Three high flow (800gpm) Hydraulic Service Manifolds with additional accumulation are typically located near the lab reaction wall to provide full flow capacity to the high speed structural actuators. For structural testing applications, these Hydraulic Service Manifolds are used for on/off control with 40 gallons each of pressure and return accumulator banks. These service manifolds each support a single actuator assembly with an 800 GPM servo valve. These Hydraulic Service Manifolds can be positioned throughout the testing Laboratory, with high speed testing typically performed at the lab reaction wall where the distribution piping and accumulator systems will maximize the flow capabilities. They can also be positioned at any free station located at the seismic table trench area if needed.

Figure 3.4.2.3-1: MTS 800 GPM Hydraulic Service Manifold

Each table system has a dedicated integral Hydraulic Service Manifold with 30 gallons each of pressure and return accumulators.

Two (2) 50gpm hydraulic service manifold are available for connecting the static actuators. Typically these manifolds are connected to the south strong floor distribution manifolds; however they can be used throughout the laboratory wherever a connection point exists.

Figure 3.4.2.3-2: MTS 293.12 50 GPM Hydraulic Service Manifold

3.4.2.4. Oil Filtration and Cleanliness

The hydraulic distribution system is designed to meet an oil filtration quality of ISO 13/10. This level of cleanliness is critical for high fidelity servo valve systems. The system is designed to use Mobil DTE 25 hydraulic fluid or the equivalent. Oil samples are taken at 3 month intervals and sent to MTS for evaluation. If particle counts exceed the ISO 13/10 specification, corrective action is immediately taken. This typically involves flushing the hydraulic distribution system at high flow rates for several hours or days, after which oil samples are again drawn for evaluation.

3.5. Loading Systems

3.5.1. Hydraulic actuators

The laboratories feature numerous actuators suitable for a variety of different testing procedures. A detailed listing of the different actuators is presented in table 1 in the lab manual.

MTS Systems Corporation servo-controlled static rated actuator (x2) with a load capacity of 440 kips (1962 kN) and an available stroke of 40 in. The actuator's servovalve has a flow rate of 15 gpm (56.78 lpm), and the actuator has a maximum velocity of 0.393 in./sec (9.982 mm/sec) with that particular valve.

Miller servo-controlled static rated actuators (x2) with a load capacity of 250 kips (1112.06 kN) and an available stroke of 8 in. (203.2 mm). The actuator's servovalve has a flow rate of 15 gpm (56.78 lpm), and the actuator has a maximum velocity of 0.65 in./sec (16.5 mm/sec) with that particular valve. Force is measured using manufacture supplied load cells and displacement is measured using internally mounted LVDTs.

MTS Systems Corporation servo-controlled dynamic rated actuator (x3) with a load capacity of 220 kips (978.61 kN) and an available stroke of 40 in.. The actuator's servovalve has a flow rate of 15 gpm (56.78 lpm), and the actuator has a maximum velocity of 0.75 in./sec (19.1 mm/sec) with that particular valve. This particular actuator is

equipped with an alternate servovalve for high speed testing which has a flow rate of 800 gpm (3000 lpm), and the actuator has a maximum velocity of 42in./sec (1066.8 mm/sec). Force is measured using a manufacture supplied load cell and displacement is measured using internally mounted LVDTs.

MTS Systems Corporation servo-controlled dynamic rated actuator (x1) with a load capacity of 220 kips (978.61 kN) and an available stroke of 10 in. (254.0 mm). The actuator's servovalve has a flow rate of 15 gpm (56.78 lpm), and the actuator has a maximum velocity of 0.75 in./sec (19.1 mm/sec) with that particular valve. This particular actuator is equipped with an alternate servovalve for high speed testing which has a flow rate of 250 gpm (946.35 lpm), and the actuator has a maximum velocity of 12.5 in./sec (317.5 mm/sec). Force is measured using a manufacture supplied load cell and displacement is measured using internally mounted LVDTs.

MTS Systems Corporation servo-controlled dynamic rated actuator (x1) with a load capacity of 110 kips (489.30 kN) and an available stroke of 10 in. (254.0 mm). The actuator's servovalve has a flow rate of 15 gpm (56.78 lpm), and the actuator has a maximum velocity of 1.5 in./sec (38.1 mm/sec) with that particular valve. This particular actuator is equipped with an alternate servovalve for high speed testing which has a flow rate of 250 gpm (946.35 lpm), and the actuator has a maximum velocity of 25 in./sec (635.0 mm/sec). Force is measured using a manufacture supplied load cell and displacements is determined using internally mounted LVDTs.

Parker servo-controlled static rated actuators (x4) with a load capacity of 70 kips (311.38 kN) and an available stroke of 4 in. (101.60 mm). The actuator's servovalves have flow rates of 15 gpm (56.78 lpm), and the actuators have a maximum velocity of 2.4 in./sec (60.96 mm/sec) with that particular valve. Due to the fact that the actuators are single-ended, they are primarily used for vertical load application. Force is measured using in-house custom built load cells and displacement is measured using external displacement transducers.

MTS Systems Corporation servo-controlled dynamic rated actuator (x1) with a load capacity of 55 kips (244.65 kN) and an available stroke of 12 in. (304.8 mm). The actuator's servovalve has a flow rate of 90 gpm (340.69 lpm), and the actuator has a maximum velocity of 17 in./sec (431.8 mm/sec) with that particular valve. Force is measured using a manufacture supplied load cell and displacement is measured using internally mounted LVDTs.

MTS Systems Corporation servo-controlled dynamic rated actuator (x1) with a load capacity of 55 kips (244.65 kN) and an available stroke of 24 in. (609.6 mm). The actuator's servovalve has a flow rate of 15 gpm (56.78 lpm), and the actuator has a maximum velocity of 2.95 in./sec (74.9 mm/sec) with that particular valve. Force is measured using a manufacture supplied load cell and displacement is measured using internally mounted LVDTs.

MTS Systems Corporation servo-controlled dynamic rated actuator (x1) with a load capacity of 22 kips (97.86 kN) and an available stroke of 6 in. (152.4 mm). The actuator's servovalve has a flow rate of 10 gpm (37.85 lpm), and the actuator has a maximum velocity of 5 in./sec (127.0 mm/sec) with that particular valve. Force is measured using an in-house custom built load cell and displacement is measured using internally mounted LVDTs

MTS Systems Corporation servo-controlled dynamic rated actuators (x2) with load capacities of 5.5 kips (24.47 kN) and an available stroke of 6 in. (152.4 mm). One actuators servovalve has a flow rate of 30 gpm (113.56 lpm), and the actuator has a maximum velocity of 50 in./sec (1270.0 mm/sec) with that particular valve. The other actuators servovalve has a flow rate of 15 gpm (56.78 lpm), and the actuator has a maximum velocity of 27 in./sec (685.8 mm/sec) with that particular valve. Force is

measured using in-house custom built load cells and displacement is measured using internally mounted LVDTs.

MTS Systems Corporation servo-controlled dynamic rated actuator (x1) with a load capacity of 2.2 kips (9.79 kN) and an available stroke of 4 in. (101.6 mm). The actuators servovalve has a flow rate of 10 gpm (37.85 lpm), and the actuator has a maximum velocity of 49 in./sec (1244.6 mm/sec) with that particular valve. Force is measured using a manufacture supplied load cell and displacement is measured using internally mounted LVDTs.

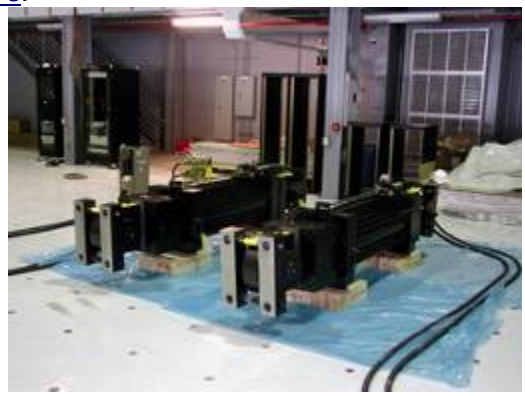


Figure 3.5.1-1: Static Actuators MTS 243.90T

Figure 3.5.1-2: Dynamic Actuators MTS 244.51S

Table 7: Performance Data of Actuators

Actuator Type/ Serial No.	Quantity	Load Capacity kips [kN]	Area in^2 [cm^2]	Stroke in. [mm]	Servovalve Type	Servo Controller	Servovalve Gpm [lpm]	Peak Velocity* in./sec [mm/sec]	Equipment Designation ***
MTS Servo-controlled Static Rated Single-ended, double acting 243.90T	2	440[1962]	146.7 [946.4]	40	MTS 252.25	MTS 406, 458, 407, FlexTest	15[56.78]	0.393[9.982]	NEES

Actuator Type/ Serial No.	Quantity	Load Capacity kips [kN]	Area in^2 [cm^2]	Stroke in. [mm]	Servovalve Type	Servo Controller	Servovalve Gpm [lpm]	Peak Velocity* in./sec [mm/sec]	Equipment Designation ***
Miller Servo-controlled Static Rated/ DH53/173393 & DH/250930	2	250 [1112.06]	83.3 [537.4]	8 [203.20]	252.25	MTS 406, 458, 407, FlexTest	15 [56.78]	0.65 [16.5]	Non-NEES
MTS Servo-controlled Dynamic Double acting 244.51S	3	220[978.61]	73.3 [472.9]	40	MTS 256.80S ****	MTS 469D, FlexTest (?)	800[3000]	42[1066.8]	NEES
					MTS 252.25	MTS 406, 458, 407, FlexTest	15[56.78]	0.75 (19.1)	
MTS Servo-controlled Dynamic Rated Double Rod/ 244.51/149	1	220 [978.61]	73.3 [472.9]	10 [254.0]	252.25	MTS 406, 458, 407, FlexTest	15 [56.78]	0.75 [19.1]	Non-NEES
					256.25	MTS 406, 458, 407, FlexTest	250 [946.35]	12.5 [317.5]	
MTS Servo-controlled Dynamic Rated Double Rod/ 244.41/160	1	110 [489.30]	36.7 [236.8]	10 [254.0]	252.25	MTS 406, 458, 407, FlexTest	15 [56.78]	1.5 [38.1]	Non-NEES
					256.25	MTS 406, 458, 407, FlexTest	250 [946.35]	25 [635.0]	
Parker Servo-controlled Static Rated Single-ended/ 1C2HLT18	4	70 [311.38]	23.3 [150.3]	4 [101.60]	252.25	MTS 406, 458, 407, FlexTest	15 [56.78]	2.4 [60.96]	Non-NEES

Actuator Type/ Serial No.	Quantity	Load Capacity kips [kN]	Area in^2 [cm^2]	Stroke in. [mm]	Servovalve Type	Servo Controller	Servovalve Gpm [lpm]	Peak Velocity* in./sec [mm/sec]	Equipment Designation ***
MTS Servo-controlled Dynamic Rated Double Rod/ 244.31/360	1	55 [244.65]	18.3 [118.1]	24 [609.6]	252.25	MTS 406, 458, 407, FlexTest	15 [56.78]	2.95 [74.9]	Non-NEES
MTS Servo-controlled Dynamic Rated Double Rod/ 244.31/393	1	55 [244.65]	18.3 [118.1]	12 [304.8]	256.09	MTS 406, 458, 469, 407, FlexTest	90 [340.69]	17 [431.8]	Non-NEES
MTS Servo-controlled Dynamic Rated Double Rod/ 204.63/503	1	22 [97.86]	7.3 [47.1]	6 [152.4]	252.24	MTS 406, 458, 407, FlexTest	10 [37.85]	5 [127.0]	Non-NEES
MTS Servo-controlled Dynamic Rated Double Rod/ 244.12/222	1	5.5 [24.47]	1.8 [11.61]	6 [152.4]	252.25 x 2	MTS 406, 458, 469, 407, FlexTest	30 [113.56]	50 [1270.0]	Non-NEES
MTS Servo-controlled Dynamic Rated Double Rod/ 244.12/585	1	5.5 [24.47]	1.8 [11.61]	6 [152.4]	252.25	MTS 406, 458, 469, 407, FlexTest	15 [56.78]	27 [685.8]	Non-NEES

Actuator Type/ Serial No.	Quantity	Load Capacity kips [kN]	Area in^2 [cm^2]	Stroke in. [mm]	Servovalve Type	Servo Controller	Servovalve Gpm [lpm]	Peak Velocity* in./sec [mm/sec]	Equipment Designation ***
MTS Servo-controlled Dynamic Rated Double Rod/ 244.00/308	1	2.2 [9.79]	0.7 [4.516]	4 [101.6]	252.24	MTS 406, 458, 407, FlexTest	10 [37.85]	49 [1244.6]	Non-NEES
Enerpac Hollow Core Jack	1	60 [267]	20 [129]	> 4 [101.6]	NA	NA	None	NA	Non-NEES
Enerpac Solid Core Jack	1	80 [355.86]	26.7 [172.3]	> 4 [101.6]	NA	NA	None	NA	Non-NEES
Enerpac Solid Core Jack	1	50 [222.41]	16.7 [107.7]	> 4 [101.6]	NA	NA	None	NA	Non-NEES

* Velocity assumes no load on actuator
** Same as previously listed actuator with different servovalve
*** Fees will not be applied to scheduled NEES projects. Fees wil be charged for extra unscheduled time. *Disclaimer: The rates are direct costs only and DO NOT include a 57% Department fee for administration and university fees. This overhead has to be added in estimates.*
**** MTS 256.80S servovalve be controlled with MTS 469D controller ONLY

3.5.1.1. Hydraulic cylinders

3.5.1.2. Servo-valves

Table 8: Performance data of Servo-valves

Servovalve Manufacturer	Quantity	Number of Stages	Flow Rate gpm [lpm]	Equipment Designation **
MTS 252.24	3	2	10 [37.9]	Non-NEES
MTS 252.25	8	2	15 [56.8]	Non-NEES
MTS 256.09	1	3	90 [340.7]	Non-NEES
MTS 256.25	2	3	250 [946]	Non-NEES
MTS 256.09*	4	3	90 [340.7]	Non-NEES
MTS 256.18*	2	3	180 [681.4]	Non-NEES

MTS 256.80S	3	3	800[3000]	NEES

* Permanent Servovalve for seismic simulator
** Fees are for servovalve substitutions only. Fees will not be applied to scheduled NEES projects. Fees wil be charged for extra unscheduled time. *Disclaimer: The rates are direct costs only and DO NOT include a 57% Department fee for administration and university fees. This overhead has to be added in estimates*.

3.5.1.3. Servo-Controllers

MTS 433 Servo-Controllers

These controllers consist of rack mounted card cages (one cage for each controlled channel). Each cage contains modular circuit cards for program input to the actuator, command vs. feedback comparison, load cell conditioning, strain gage bridge completion and conditioning, LVDT conditioning, and program error and limit detection. Due to the size and relative immobility of these controllers, they are dedicated to each of the two MTS Hydraulic Testing Machines (see table 5). While not technically part of the servo controller, a multi-waveform function generator is integral to each of the racks these controllers are mounted in.

A subset of modified MTS 433 controllers (labeled as MTS 469 controllers) is incorporated into the control system for the lab's seismic simulator. This control system provides acceleration, velocity and displacement control for the five active degrees of freedom in which the table is capable of moving. Provisions are also made for cross-coupling control to minimize the error encountered during the testing of tall and/or heavy structures.

MTS 406 Servo-Controllers

These controllers consist of portable, table top boxes which contain a main circuit board that provides program input to the actuator, command vs. feedback comparison, error/limit detection and LVDT conditioning. Plug-in cards provide load cell conditioning, third stage valve control, and other custom features as required per application. The portability of these controllers enables them to be moved and reconfigured easily and interfaced with a variety of actuators.

MTS 458 Servo Controllers

These are hybrid controllers, consisting of analog and digital technology. They can be configured as either rack mounted or free standing. They consist of a card cage with a fixed hydraulic manifold control module, and interchangeable actuator controllers. These controllers are highly configurable, providing servo control error, limit detection and signal conditioning on each card. Typically, a 458 AC Controller module is configured as the master controller, with an actuator AC LVDT as the feedback device. DC controllers for load and strain feedback (or other AC controllers) are slaved to the master controller, and switching between control modes (displacement, force, strain) is accomplished with a series of push buttons and digital readouts of the controlled variables. Generally speaking, these controllers are dedicated to specific actuators or testing machines, although they can be reconfigured with relative ease.

Table 9: Performance Data of Servo-Controllers

Servo Controller Manufacturer	Quantity (# Channels Controlled)	Control Modes	Servovalve Type(s) Controlled	Equipment Designation ****
MTS 406	8	Force / Displacement	MTS 252.24, 252.25	Non-NEES

Servo Controller Manufacturer	Quantity (# Channels Controlled)	Control Modes	Servovalve Type(s) Controlled	Equipment Designation ****
MTS 406	1	Force / Displacement	MTS 256.09	Non-NEES
MTS 433*	1	Force/ Strain/ Displacement	MTS 252.24, 252.25	Non-NEES
MTS 458**	1(2)	Force/ Strain/Displacement	MTS 252.24, 252.25	Non-NEES
MTS 458	1(2)	Force/ Strain/Displacement	MTS 252.24, 252.25 256.09, 256.25	Non-NEES
MTS 469***	1(5)	Acceleration/ Velocity/ Displacement	MTS 256.09, 256.18	Non-NEES
MTS 469D	1(5)	Acceleration/ Velocity/ Displacement	256.80S	NEES
MTS 407	5	Force / Displacement / Stress	MTS 252.24, 252.25 256.09, 256.25	NEES
MTS FlexTest	1(6)	Acceleration/ Force / Displacement	MTS 252.24, 252.25 256.09, 256.25	NEES

* Dedicated controller for MTS 150 kip Tension Machine
** Dedicated controller for MTS Axial / Torsion Testing Machine
*** Dedicated controllers for MTS/SUNY Seismic Simulator
**** Fees will not be applied to scheduled NEES projects. Fees wil be charged for extra unscheduled time. Servo controller substitution is availible for one time fee of $1200. *Disclaimer: The rates are direct costs only and DO NOT include a 57% Department fee for administration and university fees. This overhead has to be added in estimates.*

3.5.1.4. Hydraulic Service Manifolds

Hydraulic Service Manifold (HSM) is a hydraulic pressure and flow regulation device that controls pressure to a single test station from the main hydraulic power unit (HPU).

Table 10: Performance Data of Hydraulic Service manifolds

Device Type	Quantity	Flow Rate (per unit) gpm [lpm]	Equipment Designation
MTS506.81 HPS	2	140* [1245.5]	Non-NEES
MTS Manifold 290 Series	3	50 [189]	Non-NEES

Device Type	Quantity	Flow Rate (per unit) gpm [lpm]	Equipment Designation
MTS Manifold 290 Series	2	100 [378.54]	Non-NEES
MTS Manifold 290 Series	1	250[946.35]	Non-NEES
MTS Model 506.92 HPS	4	180**[680]	NEES
MTS High Flow Hydraulic Distribution Manifolds	4	800	NEES
Custom Hydraulic Service manifolds	3	800	NEES
MTS 293.12 Low Flow Hydraulic Service Manifold	2	50[189]	NEES

Flow Rate available in increments of 70 gpm (265 lpm) , ** Flow Rate available in increments of 90 gpm (340 lpm)

3.5.1.5. Integration options – actuators, controllers, manifolds

It is important to understand that the laboratory is not restricted to the specifications of each particular hydraulic actuator. In an actual experiment a hydraulic actuator system is composed of three major components including the hydraulic cylinder, servovalve, and servo-controller. Due to the fact that the majority of the equipment used in the laboratories is manufactured by MTS Systems, the components of each actuator can be interchanged. Different servovalves can be used on the same hydraulic cylinder to produce low and high speed velocities. This in turn may change the rating of the hydraulic actuator from static to dynamic and vice versa.

Moreover, different servo-controllers may be used depending on the desired experimental set up. For example, an experiment may entail applying a force to a horizontal beam and at the same time ensuring that the beam is kept horizontal. This would require an initial actuator to apply force to the system as well as a second actuator to ensure that the position of the beam is correct. Different servo-controllers can be used that will allow the system to obtain actual feedback from the two actuators so that any necessary corrections can be made immediately. Refer to Table 2 for a complete list of the available servo controllers.

3.5.2. Testing Machines

3.5.2.1. MTS Universal Tension Machine - 150 kip (667kN)

This is a low speed machine capable of tension or compression testing of specimens or components composed of steel, concrete, rubber or other materials. The force range is adjustable to calibrated ranges of 200, 100, 40, and 20 kips, and the displacement range is adjustable to ± 4, 2, 1, and .5 in. for applications where greater

sensitivity is required. The machine can be controlled in either force or displacement mode

Figure 3.5.2.1-1: MTS Universal Tension Machine

3.5.2.2. MTS Axial-Torsion Machine

This machine is capable of biaxial testing of specimens and components of many sizes, up to 4 ft. (1.22 m) in length. Control modes available are force, strain and displacement in axial mode, and torque (in/lb.), strain and rotation (degrees) in torsion mode. The machine has calibrated ranges of 100, 50, 20, and 10 kips, and $\pm$ 5, 2.5, 1, and .5 in. axially, as well as 50000, 25000, 10000, and 5000 inch-pounds, and 50, 25, 10, and 5 degrees in the torsion mode.

Figure 3.5.2.2-1: MTS Axial-Torsion Machine

3.5.2.3. Generic Large Bearing Testing Machine

This machine has been developed for the testing of sliding bearings. It is capable of 1600 (7117.2kN) kips compression (expandable to 2200 kips / 9786.1kN), lateral load of up to 220 kips (978.6kN), stroke of $\pm$ 5 in. (12.7 cm) and velocities of up to 10 in./sec (254 mm/sec). Bearing plan dimensions can be up to 45 in. (114.3 cm) by 45 in. (114.3 cm). It can be used for the seismic testing of sliding bearings and the characterization of frictional properties of large-dimension material interfaces. The machine can also be

used for the testing of elastomeric bearings. The machine is capable of testing pairs of bearings, or a single bearing with the use of rolling cylinders. Figure 9 presents a view of this testing machine.

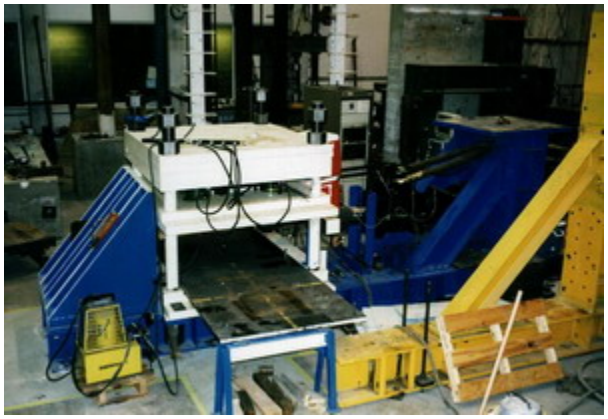


Figure 3.5.2.3-1: Large Bearing Testing Machine

3.5.2.4. Generic Small Bearing Testing Machine

This machine has been developed for the testing of single bearings under controlled conditions of vertical load, lateral movement and rotational movement. It has a 140 kip (622.8kN) vertical load capacity, 55 kip (244.7 kN) horizontal load capacity, $\pm$ 6 in. (15.24 cm) horizontal movement capacity with up to 15 in./sec (381 mm/sec) velocity, and rotational capability of $\pm$ 2 degrees. Reaction forces can be directly measured by a multi-component load cell which currently has a rated capacity of 20 kips (89 kN) shear and 50 kips (222.4 kN) axial load. The machine can been used in the testing of elastomeric and sliding bearings, including tests under variable axial load and tests of bearings pre-stressed by tendons to prevent uplift. Figure 10 presents a view of the testing machine during testing of an elastomeric bearing.

Figure 3.5.2.4-1: Small Bearing Testing Machine

3.5.2.5. Tinius-Olsen Universal testing Machine–300 kips (1350kN)

This machine has been used primarily for testing concrete cylinders, structural steel members, and standard steel test specimens. The machine consists of a dual

crosshead, mechanical screw load frame, with a test surface platen having an effective area of 31 in. (79 cm) x 43 in. (109 cm). The platen is 45 in. (114.3) from the lab floor. The crossheads can be placed at any height along the screws to allow testing of specimens up to 72 in. (183 cm) long in tension. The upper crosshead is locked in place during testing, while the lower crosshead moves along the machine's screws to apply tension or compression to the specimen. Compression testing capacity is limited by the tendency of tall specimens to buckle, but theoretically a 72 in.(183 cm) specimen can also be tested in compression. The machine is capable of testing specimens in tension or compression to 300 kips (1334kN). Force readout is provided by a dial indicator calibrated in ranges of 3, 12, 60 and 300 kips (13. 53, 267, and 1334kN). For electronic readout, any suitable load cell can be mounted in series with the test specimen. Alternatively, a Temposonic displacement transducer is mounted on the gear rack assembly which drives the dial indicator, providing a linear voltage readout proportional to the position (force readout) of the dial indicator. Displacement readout is accomplished by using displacement transducers of suitable range mounted parallel to (or directly on) the test specimen.

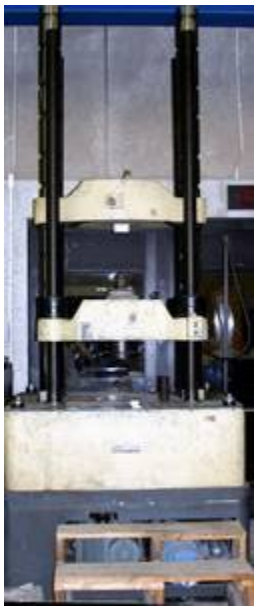


Figure 3.5.2.5-1: Tinius-Olsen Universal Testing Machine

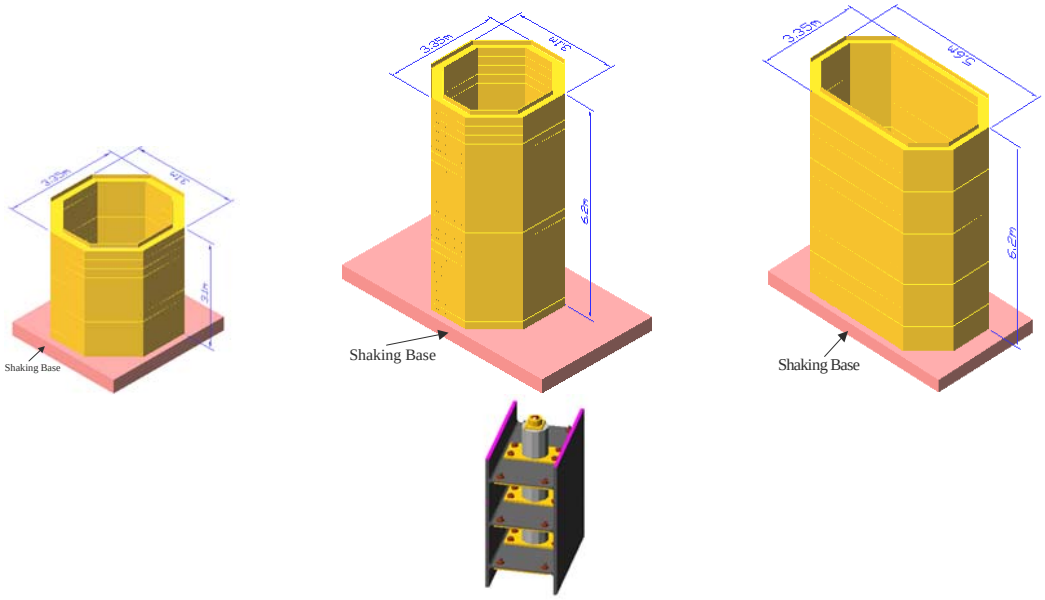
3.6. Other Testing Systems

3.6.1. Geotechnical Laminar Box

3.6.1.1. Geometry

The UB Full-scale prototype 1-g soil and soil-structure interaction testing facility consists of a 2-D modular laminar box (Module A1: 2.75x5x6.2m, internal dimensions). The 2-D laminar box is made of 24 laminates, separated and supported by ball bearings, facilitating 2-D motions, including ability to simulate sloping ground subjected to large deformations. The box can simulate boundary stresses closely to that of a free ground. The laminar box can also be reconfigured into two other configurations or modules (module B1: two boxes 2.75x2.5x3.1m each or module B2: 2.75x2.5x6.2m) or at a reduced height. The box can allow up to 15% shear strain in general, larger deformations for selected cases of loadings, and large permanent deformations on a

case-by-case basis, subject to safety and other limitations. Figures 3.6.1.1-1-3 present schematic diagrams of the laminar box modules. Figure 3.6.1.1-4 shows a picture of the laminar box.



(a) Module B1: 2.75x 2.5x3.1 m (b) Module B2: 2.75x 2.5x6.2 m (c) Module A1: 2.75x5x6.2m
(d) 2-D Bearing
(e) Module A2: 2.75x5x3.2 m (not shown)

Figure 3.6.1.1-1: 2D Laminar Box Modules at SEESL

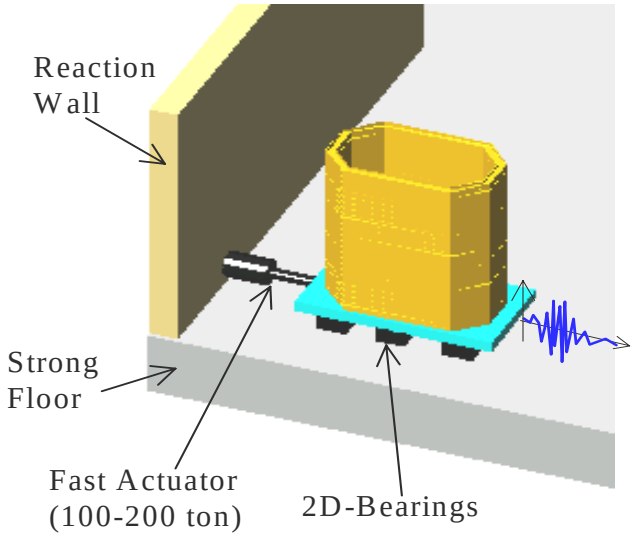


Figure 3.6.1.1-2: Laminar Box (1-g Full scale Tests) on the Strong Floor

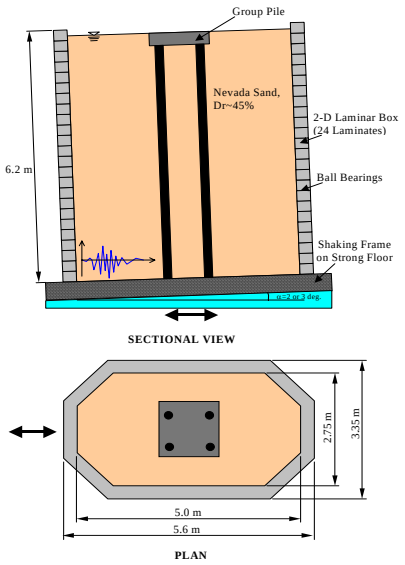


Figure 3.6.1.1-3: A typical pile test configuration

Figure 3.6.1.1-4: Laminar Box in Test Area 2

3.6.1.2. Features

Table 11: Laminar Box Module Dimensions & Details

Module	A2	B1 and B2	A1
Box-Internal Base Size (mxm)	2.75x5	2.75x2.5	2.75x5
Box-Height (m)	3.1	6.2 or 3.1	6.2

Module	A2	B1 and B2	A1
Box-Metal Weight (empty) (tons)	8.5	11.2 or 5.6	17.0
Box-Max Soil Vol. (m^3)	38.6	34.6 or 17.3	77.2
Support	Steel-bridge-spanning two tables	Steel-bridge-spanning two tables (6.2m) or on a single table (3.1m)	Strong Floor
Number of Laminates	12	24 (or 12)	24
Laminate Thickness (m)	0.26	0.26	0.26
Interlaminate Bearings	Ball Units	Ball Units	Ball Units
Spanning-Base Steel Bridge (tons)	7.5	7.5	7.5
Payload Capacity	40g-ton	40 g-ton (6.2m) or 20 g-ton (3.1m)	0.3g max
Maximum Weight (incl box & soil)	100 tons	100 tons (6.2m) or 50 tons (3.1m)	185 tons
Shaking Dir.	Horiz: X, Y	Horiz: X, Y	Horiz: X or Y
Inter-laminate displ. (nominal) limit (mm)	36	36	36
Inter-laminate displ. (for special tests) limit (mm) (may increase this limit for 1-D tests)	74	74	74
Permanent Displacement between Laminate	To be decided on a case-by-case-basis	To be decided on a case-by-case-basis	To be decided on a case-by-case-basis

Table 11 presents the dimensions and details of the various modules. The load capacity characteristics are to be considered preliminary, subject to verification and update. In its largest configuration (Module A1: 2.75x5x6.2m), the laminar box is supported on the strong floor, on a steel shaking base frame supported on rubber/sliding bearings. It can be actuated in 1-D using one or more of the UB-NEES 100 ton fast dynamic actuators (MTS), or in 2-D by using two or more 100 tons fast actuators mounted at 45 degrees on the new UB-NEES reaction wall (30ft high, 41ft wide). The total weight of the box filled with sand is about 150-170 tons, whereas the maximum horizontal dynamic actuator capacity is 90 tons in each horizontal direction simultaneously or 180 tons in any one direction. Thus very large shaking g levels are possible. The actuators can be fed with any recorded motion and the controllers can be set to compensate for any compliance effects to accurately shake the base of the soil to meet any desired recorded earthquake motion. Data acquisition systems are available to monitor up to 256 channels at high frequencies. High resolution imaging tools can be positioned to capture deformation patterns at any selected zone in the soil box.

In its smaller configurations (modules A2, B1 and B2), the laminar box may be mounted on a shake table with a maximum payload capacity of 50 tons weight including the box weight. Where higher weights are expected the box may be assembled over a steel base frame supported by two identical shake tables allowing up to 100 tons maximum weight, including the weight of the box and the steel base frame. The shake table payload-acceleration characteristics are presented elsewhere. Typically each shake table can operate at up to 1.15g at a nominal payload weight of 20 tons, and the acceleration decreases with an increase in payload weight. The shake tables have 6 degrees of freedom, but the 1-g soil tests are limited to 1-D or 2-D at this time.

Sand may placed inside the box by air pluviation, wet pluviation, or hydraulic filling. Due to dust control considerations the hydraulic filling method is preferred. A close-loop system has been developed to pump sand-slurry using sand-slurry pump from sand containers located just outside the Test Area 2 building. In the case of dry pluviation, soil saturation may be achieved by percolating by CO_2 through the soil and seeping water with the aid of vacuum suction.

The facility also has capability to simulate the inertial effects of the building/bridge pier etc. on the foundation/pile cap via mass-spring system and/or hybrid system where the loads/moments from the building/bridge pier can be applied via fast actuators mounted on the reaction wall. The soil experiments also can be coupled with other physical experiments at UB or elsewhere and/or computational models that simulate the response of the system or structure supported on the soil.

3.7. Instrumentation

3.7.1. Sensors

3.7.1.1. Motion

3.7.1.1.1. Displacement

The laboratory uses many different types of displacement transducers that each have various attributes and limitations which determine their suitability for different applications. The following is a list of each different displacement transducer and a brief summary of its mechanics.

Linear Potentiometers

The most readily available and simplest position transducer is a linear potentiometer excited by a DC source such as a battery. It may be hooked up to deliver an output voltage that is essentially proportional to a straight-line position varying between zero and a maximum. Alternatively, a potentiometer may be hooked up to deliver an output varying between a negative and positive voltage in proportion to a mechanical displacement that also varies between a maximum negative and a maximum positive value relative to a defined null position.

Linear Variable Differential Transformer (LVDT)

The word "linear" appears in the name of the LVDT to denote straight-line motion as opposed to a linear relationship between input and output. Three coils of electrically conducting wire are wound on an insulating form. By the principle of mutual inductance an AC voltage across the terminals of the primary coil induces a voltage of the same frequency in each of the two secondary coils. If the moveable ferromagnetic core is centered, the two secondary voltages are of the same amplitude. For a positive displacement of the core, the voltage appearing across the number 1 secondary coil is greater in amplitude than at the null condition, while the amplitude across the number 2 secondary coil is less.

MTS Temposonic Displacement Transducer

Initially a current pulse is applied to the conductor within the waveguide over its entire length. There is another magnetic field generated by the permanent magnet that exists only where the magnet is located. This field has a longitudinal component. These two fields join vectorially to form a helical field near the magnet which in turn causes the waveguide to experience a minute torsional strain or twist only at the location of the magnet. This torsional strain pulses propagates along the waveguide at the speed of sound in this material. When this torsional pulse arrives at the tapes in the head it is converted into a dynamic longitudinal pulse injected into the tapes. The longitudinal pulses cause the tapes to experience a momentary change in reluctance. Two coils coupling these tapes mounted in the field of two bias magnets will generate a momentary electrical pulse caused by the change in reluctance in the tapes. In order to extract the useful position information we measure the time between when we launch

the initial current pulse and the time we receive the signal from the output coils. This time is a very precise function of the position of the moving magnet.

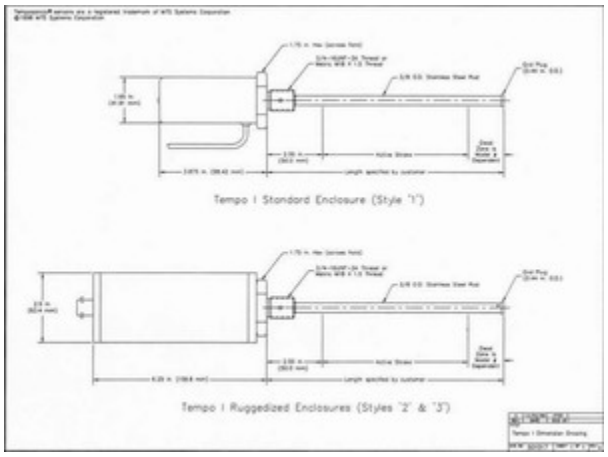


Figure 3.7.1.1.1-1: Temposonic 1 Dimension Drawing

3.7.1.1.2. Acceleration

Piezoresistive Accelerometer

This type of accelerometer, also known as a strain gage accelerometer, is similar in principle to a piezoelectric accelerometer except it is equipped with a built in resistor, which allows it to be used with a standard signal conditioner.

Table 7 presents a summary of the available transducers (excluding load cells) and their range of measurement.

Table 12: Available Transducers

Device Type	Measured Quantity	Quantity	Measurement Range	Equipment Designation *
Linear potentiometer	Displacement	20	± .25 : ± 2.0 in. [± .64 : 5.08 cm]	Non-NEES
Linear potentiometer	Displacement	110	± 20 in.	Non-NEES
Linear potentiometer	Displacement	2	± 5 in.	Non-NEES
LVDT	Displacement	15	± .5 : ± 2.0 in. [± 1.27 : 5.08 cm]	Non-NEES
MTS Temposonic Transducer	Displacement	13	4 in. [10.16 cm]	Non-NEES
MTS Temposonic Transducer	Displacement	4	8 in. [20.32 cm]	Non-NEES
MTS Temposonic Transducer	Displacement	3	10 in. [25.4 cm]	Non-NEES

MTS Temposonic Transducer	Displacement	3	16 in. [40.64 cm]	Non-NEES
MTS Temposonic Transducer	Displacement	6	20 in. [50.8 cm]	Non-NEES
MTS Temposonic Transducer	Displacement	2	30 in. [76.2 cm]	Non-NEES
Shaevitz RVDT R30D	Rotation	4	0 : 30 degrees	Non-NEES
Endevco Piezoresistive Accelerometer	Acceleration	8	0 : 25 g	Non-NEES
Sensotec Piezoresistive Accelerometer	Acceleration	150	0 : 10 g	NEES
Kistler	Acceleration	2	0:10 g	Non-NEES
Kistler	Acceleration	8	0:2.5 g	Non-NEES
PCB	Acceleration	2	0:3 g	NEES
PCB	Acceleration	22	0:10 g	NEES
Kulite Piezoresistive Accelerometer	Acceleration	15	0 : 10 g	Non-NEES
MTS Temposonic II	Displacement	15	4-20 in.	NEES

* Fees will not be applied to scheduled NEES projects. Fees will be charged for extra unscheduled time. *Disclaimer: The rates are direct costs only and DO NOT include a*

3.7.1.1.3. Rotation

The laboratory uses rotational transducers that also have various attributes and limitations which determine their suitability for different applications. The following is a brief summary of its mechanics.

Rotary Variable Differential Transformer (RVDT)

RVDTs incorporate a proprietary noncontact design that dramatically improves long term reliability when compared to other traditional rotary devices such as syncros, resolvers and potentiometers. This unique design eliminates assemblies that degrade over time, such as slip rings, rotor windings, contact brushes and wipers, without sacrificing accuracy.

High reliability and performance are achieved through the use of a specially shaped rotor and wound coil that together simulates the linear displacement of a Linear Variable Differential Transformer (LVDT). Rotational movement of the rotor shaft results in a linear output signal that shifts ±60 (120 total) degrees around a factory preset null position. The phase of this output signal indicates the direction of displacement from the null point. Noncontact electromagnetic coupling of the rotor provides infinite resolution, thus enabling absolute measurements to a fraction of a degree.

Although capable of continuous rotation, most RVDTs are calibrated over a range of ±30 degrees, with nominal nonlinearity of less than ±0.25% of full scale (FS).

Extended range operation up to a maximum of ±90 degrees is possible with compromised linearity.

R30D

The R30D RVDT is a DC operated noncontacting rotary transducer. Integrated signal conditioning enables the R30D to operate from a bipolar ±15 VDC source with a high level DC output that is proportional to the full range of the device. Calibrated for operation to ±30 degrees, the R30D provides a constant scale factor of 125 mVDC/degree. Nonlinearity error of less than ±0.25% FS is achieved while maintaining superior thermal performance over -18°C to 75°C.

3.7.1.2. Loading

Load Cells

Due to the fact that many of the test apparatuses are specifically developed for single experiments, in-house custom built load cells are often used. The geometric layout of a typical load cell is shown in Figure 11. They are fabricated from a thick wall cylindrical steel tube. The turned down wall thickness, height, and radius are determined based on the expected maximum stresses in the load cells during testing.

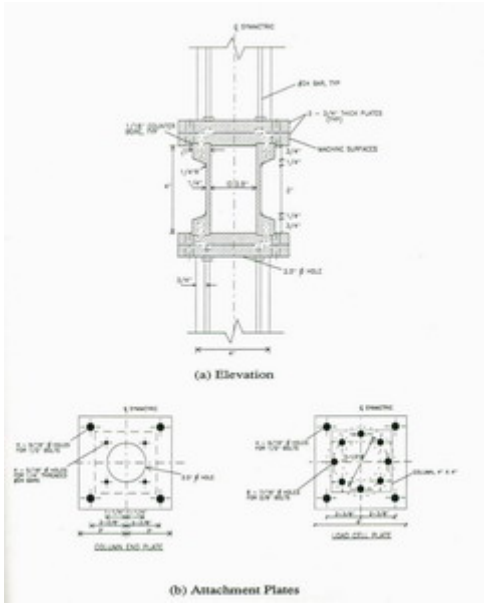


Figure 3.7.1.2-1: **Geometric Layout of Typical Load Cell**

The attachment plates ensure a uniform stress distribution over the entire load cell and provide anchorage into the columns. In the most complicated custom built load cells, axial, shear, and moment stresses can be measured from Wheatstone bridge circuits wired according to Figure 12. Simpler compression-tension load cells are also commonly built using only an axial Wheatstone bridge circuit.

In addition a majority of the MTS, Miller, and Parker Actuators were purchased with a load cell provided by the manufacturer. These load cells are often used in experimentation.

For more detail on our 6” Five-Component Load Cell in-house made Load Cells please refer to this document:

Load Cells Drawings and Calibrations

Delta P Cells

Delta P cells are used on many of the actuators available in the laboratories. The MTS servo controllers utilize the Delta P (differential pressure) measured across the actuator piston as a stabilizing variable during the control of an actuator's motion.

Table 6 lists the different available load measuring devices**.**

Table 13 : **Available Load Measuring Devices**
Load Units Kips[kN], Moment Units Kips-Inch [kN-m]

Load Measuring Device Type	Quantity	Load Capacity	Use	Calibration Interval	Equipment Designation *
5.5" Five-Component Load Cell 5D-LC-5.5-YEL (axial, x & y shear, x & y moment)	16	Axial : 30 [133.6] Shear : 5 [22.3] Moment: 30 [3.39]	Shake Table & Floor Testing	As Needed	Non-NEES
12" Five-Component Load Cell 5D-LC-12-BLU (axial, x & y shear, x & y moment)	4	Axial : 100 [454.5] Shear : 20 [89] Moment 220 [24.86]	Shake Table & Floor Testing	As Needed	Non-NEES
12" Five-Component Load Cell 5D-LC-12-RED (axial, x & y shear, x & y moment)	4	Axial : 100 [454.5] Shear : 20 [89] Moment 220 [24.86]	Shake Table & Floor Testing	As Needed	Non-NEES
12" Five-Component Load Cell 5D-LC-12-BLK (axial, x & y shear, x & y moment)	4	Axial : 100 [454.5] Shear : 20 [89] Moment 220 [24.86]	Shake Table & Floor Testing	As Needed	Non-NEES
Axial (Various) (compression:tension)	10	2 – 250 [8.9– 1112.06]	Shake Table & Floor Testing	As Needed	Non-NEES
Washer (compression only)	8	100 [454.5]	Shake Table & Floor Testing	As Needed	Non-NEES

MTS Load Cell	1	2.2 [9.79]	On MTS Actuator	2 Years	Non-NEES
MTS Load Cell	2	55 [244.65]	On MTS Actuator	2 Years	Non-NEES
MTS Load Cell	1	110 [489.30]	On MTS Actuator	2 Years	Non-NEES
MTS Load Cell	1	220 [978.61]	On MTS Actuator	2 Years	Non-NEES
Lebow Load Cell	2	250 [1112.06]	On Miller Actuator	2 Years	Non-NEES
Custom Built Load Cell	4	70 [311.38]	On Parker Actuator	One Year – Local Calibration	Non-NEES
MTS Load Cell Model 661.31E-01	3	220 [978.61]	On MTS Actuator	2 Years	NEES
MTS Differential Pressure Cell 660.23	5	5000 psi [35 MPa]	On MTS Actuator	2 Years	NEES

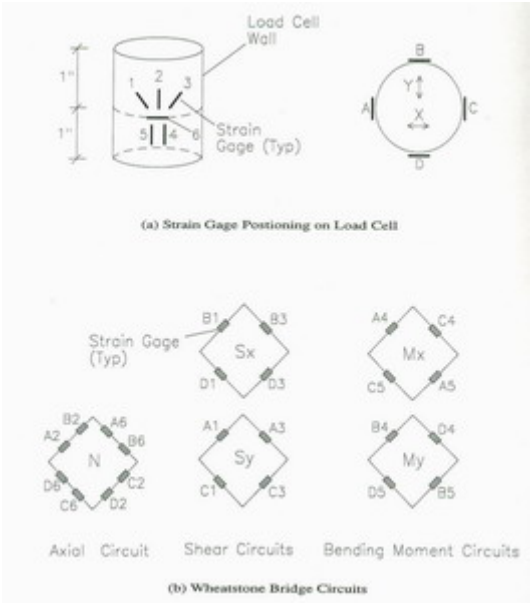


Figure 3.7.1.2-2: Typical Strain Gage Positioning and Wiring for Multidirectional Load Cells

3.7.1.3. Strain

The Strain Gauge

While there are several methods of measuring strain, the most common is with a strain gauge, a device whose electrical resistance varies in proportion to the amount of strain in the device. The most widely used gauge is the bonded metallic strain gauge.

The metallic strain gauge consists of a very fine wire or, more commonly, metallic foil arranged in a grid pattern. The grid pattern maximizes the amount of metallic wire or foil subject to strain in the parallel direction (Figure 3.7.1.3-1). The cross sectional area of the grid is minimized to reduce the effect of shear strain and Poisson Strain. The grid is bonded to a thin backing, called the carrier, which is attached directly to the test specimen. Therefore, the strain experienced by the test specimen is transferred directly to the strain gauge, which responds with a linear change in electrical resistance. Strain gauges are available commercially with nominal resistance values from 30 to 3000 Ω, with 120, 350, and 1000 Ω being the most common values.

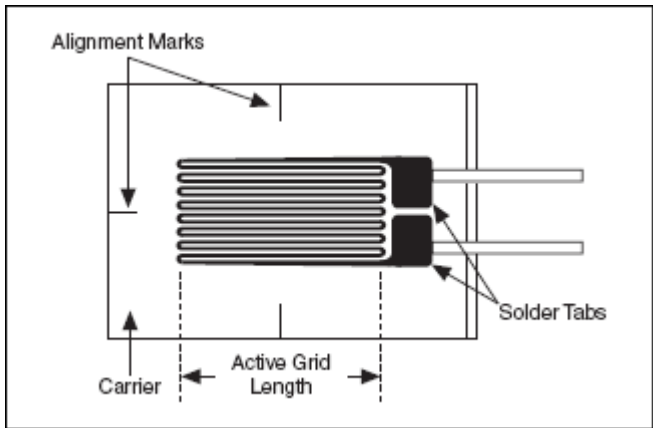


Figure 3.7.1.3-1: Bonded Metallic Strain Gauge

It is very important that the strain gauge be properly mounted onto the test specimen so that the strain is accurately transferred from the test specimen, though the adhesive and strain gauge backing, to the foil itself. A fundamental parameter of the strain gauge is its sensitivity to strain, expressed quantitatively as the gauge factor (GF). Gauge factor is defined as the ratio of fractional change in electrical resistance to the fractional change in length (strain):

$$GF = \frac{\Delta R/R}{\Delta L/L} = \frac{\Delta R/R}{\varepsilon}$$

The Gauge Factor for metallic strain gauges is typically around 2.

Table 14: Available strain gauges

Strain Gauge Type	Quantity	Model No.	Calibration Interval	Equipment Designation *
Uni-axial strain gage	275	CEA-06-125UW-120	As Needed	Non-NEES

3.7.1.4. Video

For video recording of experiments, lab is equipped with three HD (High Definition) camcorder, 12 PTZ cameras and 10 CCD cameras with integrated microphones.

HD camcorder is JVC DIGITAL HD CAMCORDER JY-HD10U that has following features:

- High Definition Recording Capability:
  - 720/30P (MPEG2)
  - 480/60P (MPEG2)
- High Definition Playback Capability:
  - 1080/60i
  - 720/60P
  - 480/60isn
  - 480/60i 4:3
- Standard definition Recording/Playback
- 480/60i 4:3 Recording on Standard Mini DV Tape
- Lens for HD video image x10, F1.8
- Optical image stabilizer system: with on/off switch
- 1/3-inch 1.18 Mega-pixel progressive scan CCD (Single chip)
- 16:9 still image capture, MPEG-4 clip capture with SD memory card
- Real time video streaming possible via USB interface to PC

Figure 3.7.1.4-1: JY-HD10U Camera

12 PTZ cameras are 4 Canon VC-C4R Cameras and 8 Canon VC-C4 Cameras.

Table 15: Canon VC-C4/VC-C4R Camera Specification

Total number of Pixels	470000 (440000 effective) pixels
Resolution Horizontal/Vertical	420 TV lines / 350 TV Lines
Zoom	16x Power Zoom
Focus	Auto/Manual
Aperture	Auto Iris Servo System
Pan Angle Range	±100º (vc-c4) ±170º (vc-c4r)

Pan/Tilt Rotation Speed	Pan: 1 to 90 deg/s, Tilt: 1 to 70 deg/s
Video Out	RCA pin jack
S Video Out	1 mini-DIN 4-pin
RS-232C	in:Mini 8-pin DINx1, out:Mini 8-pin DINx1
DC Input	Dedicated AC adapter
Cascade Control	up to 9 cameras
Dimensions	100 (W) x 112 (D) x 89.5 (H) mm
Weight	375g / 440 g

Figure 3.7.1.4-2: Canon VC-C4 and VC-C4R Cameras

10 CCD cameras are VC-806b-audio models with following features:

- Audio: AUDIO MAX 2Vp-p 50 Ohm
- Signal System: NTSC
- Image Sensor: 1/4" **SONY Super HAD CCD**
- Effective Pixels: 510 x 492
- Horizontal Resolution: 380TV lines
- Lens: 3.6mm/92° Angle of View
- S/N Ratio: > 48dB
- Min. Illumination: 1.0Lux/F1.2
- White Balance: Auto tracking
- Shutter Speed: 1/50(1/60)-1/100,000 sec
- Video Output: 1.0Vp-p 75 Ohm
- Power Consumption: 12VDC, 120mA
- Dimensions: 1.44" x 1.44" x 0.82"

Figure 3.7.1.4-3: VC-806b-Audio Camera

3.7.1.5. Images – Still

Lab is equipped with two Digital SLR cameras: Canon EOS 10D and 20D for still image photography of the experiments.

Table 16: 10D and 20D Specifications

	EOS-20D	EOS-10D
Sensor Type	22.5 x 15.0mm CMOS w/ RGBG filter	22.7 x 15.1mm CMOS w/ RGBG filter

	EOS-20D	EOS-10D
Sensor Resolution (total)	8.8 mega pixels	6.5 mega pixels
Sensor Resolution (effective)	8.25 mega pixels	6.3 mega pixels
Lens Compatibility	EF and EF-S	EF only
mage Processor	DIGIC II	DIGIC
Connectivity	USB 2.0	USB 1.1
Flash Metering	E-TTL II	E-TTL

Figure 3.7.1.6-1: 20D and 10D side by side

Figure 3.7.1.6-2: 20D and 10D back to back top view

3.7.2. Conditioners

Listed below are the available signal-conditioning channels, charge amplifiers and power supplies. Table 8 presents a summary of the available equipment.

90 channels of Measurement Group 2300 DC Series signal conditioning which can be used with full, half, and quarter bridge configurations. This signal conditioner allows the use of either 120 or 350 ohm strain gages in a quarter bridge configuration

and the amplification can be set in the range of 1 to 11000. The excitation voltage can be easily adjusted using a front panel control in the range of 0.7 to 15.0 volts.

24 channels of Measurement Group 2100 DC series signal conditioning which can be used with full, half, and quarter bridge configurations. This signal conditioner allows the use of either 120 or 350 ohm strain gages in a quarter bridge configuration and the amplification can be set in the range of 1 to 220. The excitation voltage can be easily adjusted using a front panel control in the range of 0.0 to 10.0 volts.

Miscellaneous DC power supplies, built in - house, are used to supply input voltage to linear potentiometers and Temposonic Displacement Transducers (section 2.5.2). They are built, configured and maintained as needed.

Table 17 : Available Signal Conditioners

Signal Conditioner Type	Number of Channels	Gain Range	Bridge Configurations Supported	Quarter Bridge Strain Gage Resistance (Ohms)	Excitation (volts)	Equipment Designation
Measurement Group 2300 DC	90	1-11000	Full, Half, Quarter	120, 350	0.7-15.0	Non-NEES
Measurement Group 2100 DC	20	1-220	Full, Half, Quarter	120, 350	0.0-10.0	Non-NEES
Generic Potentiometer power supply	20	NA	NA	NA	± 10.0	Non-NEES
Generic Temposonic power supply	35	NA	NA	± 15.0	15.0	Non-NEES
Misc. (standalone charge amps, etc.)	15	NA	NA	NA	NA	Non-NEES

3.7.3. Electronic Instruments

3.7.3.1. Oscilloscopes

The laboratories currently support one 4-channel storage oscilloscope, used mostly for instrumentation calibration and verification of signal integrity. The oscilloscope is a Tektronix model TDS224, and has storage and data acquisition functionality.

3.7.3.2. Digital Multimeters and Voltage Standards

The lab maintains several digital multimeters, all of which are calibrated annually and are used as reference standards for in-house calibrations. Calibration data sheets are available to users who wish to verify quality of measurements

3.7.4. Instrumentation frames

SEESL is equipped with 3 instrumentation frames. One orange frame is located next to Shake Table O in Test Area 1. Two blue frames are located next to Shake Tables A and B in Test Area 2. These frames are reference frames and are used in specimen instrumentation.

Figure 3.7.4-1: Orange Instrumentation Frame

Figure 3.7.4-2: Blue Instrumentation Frame

3.7.5. Instrumentation Databases

3.7.5.1. Instrumentation calibration

3.7.5.1.1. Lab procedures

Most of the in-house built lab equipment is calibrated on need to basis. The most recent calibration certificates as well as calibration procedures can be accessed at calibration section of SEESL (nees@buffalo) website.

3.7.5.1.2. Calibration examples and databases

Calibration records as well as procedures can be accessed through the calibration section on SEESL (nees@buffalo) website.

3.8. Data Acquisition Systems

3.8.1. Pacific Instruments

The 6000 Mainframe has an IEEE-488 interface for control and data output with mounting for 16 input and output modules. It supports up to 31 additional slave enclosures or up to 32,000 channels. Currently it is configured for 132 channels.

The Mainframe is running Version 8.1 of PI660 software for the 6000 DAS. That includes a variety of new features. Among the new features is the ability to acquire data simultaneously from multiple input sources. Version 8.1 includes support for the ICS-610 and ICS-645 high-speed sigma-delta digitizer boards. Each ICS-610 has the ability to digitize up to 32 channels of analog signals at a rate of 100,000 samples per second per channel. Each ICS-645 has the ability to digitize up to 32 channels of analog signals at a rate of 2,500,000 samples per second per channel. The PI660 software currently supports up to 10 of the ICS boards per system.

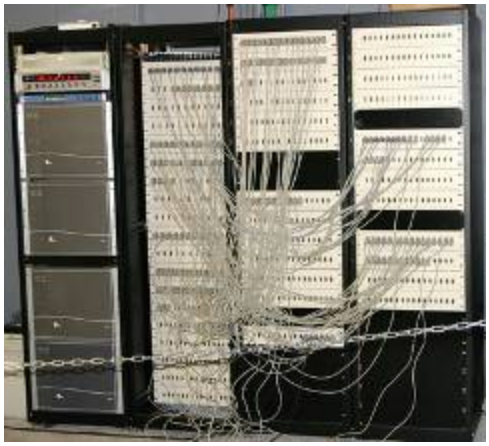


Figure 3.8.1-1: **Pacific Instruments 6000 Data Acquisition Mainframe**

3.8.2. Optim MegaDac

This is a modular, expandable system, currently configured with 128 channels of sample & hold A/D input, along with 8 channels of thermocouple conditioning and 8

output channels for playback. The Megadac is primarily used in the original Seismic laboratory for various test programs.

Figure 3.8.2-1: Optim Megadac DAQ

3.8.3. Krypton K600 Portable CMM System

The K600 is a new generation of high performance dynamic mobile coordinate measurement machine. The system combines high accuracy, a large measurement volume and full freedom of Space Probe manipulation. This solid-state system is extremely reliable.

Figure 3.8.3-1: Krypton K600 Portable CMM System

Capabilities (abbreviated):

Measurement system / probes capabilities:

1 LED	3 degrees of freedom
3 (or more) LED	6 degrees of freedom

Sampling rate:

Rate = 3000 / # of LED (in samples per second)
i.e. for 20 active LED's the Rate = 150 samples per second
for 50 active LED's the Rate = 60 samples per second

Field of view for K600:

Minimum distance (D) from camera 1.5 m; Maximum distance (D) from camera xx m.

The field of view is defined as noted below (H = height of image, W- width of image, D = the distance from which the max view can be captured). H and W can be interchanged. Here are the manufacturer specified field views:

Table 18: Field of view for K600

	H	W	D
0	0.9m	0.5m	1.5m (min)
I	1.7m	1.8m	3.5m (max)
II	2.4m	3.3m	5.0m (max)
III	2.6m	3.6m	6.0m (max)

Field-of-view: 17 m³, distributed into three accuracy zones as follows:

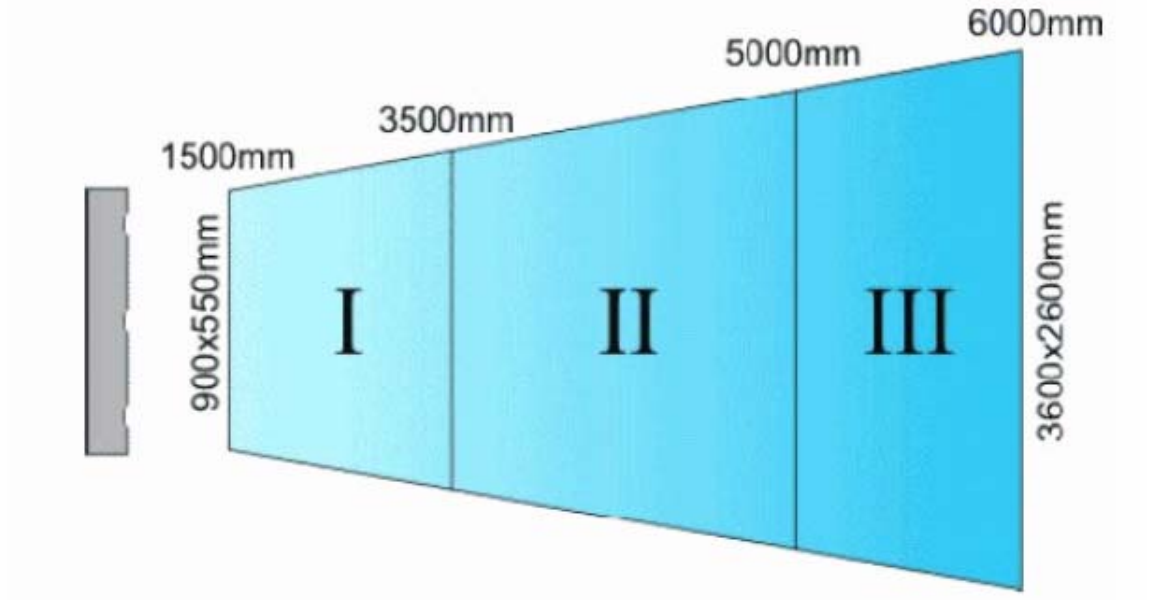


Figure 10: camera field-of-view

Additional performance limitations see Figure 3.8.3-2:

Accuracy :

Single Point :	0,060 mm
Volumetric :	0,090 mm + 0,010 mm/m

The indicated measurement uncertainty is expressed for a confidence level of 95%, according to the ISO 10360 II, VDI 2617 and ANSI / ASME B89.1.12M standards for acceptance of CMMs.

Acquisition frequency :

Important notice: The K400 camera system can ***not*** *be used for dynamic measurements.*

The measurement frequency for static measurements is set to 10Hz.

K600 CAMERA UNIT

Field-of-view: 17 m³, distributed into three accuracy zones as follows:

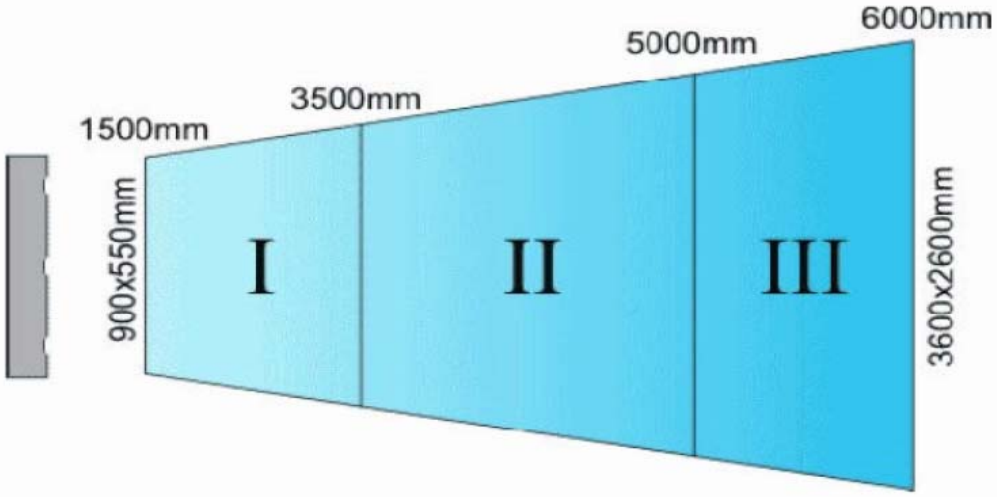


Figure 10: camera field-of-view

Resolution : 0,002 mm at 2,5 mm

Noise (1σ) : 0,010 mm

Accuracy :

Zone	Volumetric Accuracy (±2σ)	Single Point Accuracy (±2σ)
I	90µm + 10µm/m	60µm + 7µm/m
II	90µm + 25µm/m	60µm + 17µm/m
III	190µm + 25µm/m	130µm + 17µm/m

Figure 3.8.3-2: Performance limitations of K600

3.8.4. Dell Workstations – Portable DAQ

These systems (3 total) each consist of 16 channels of National Instruments 16 bit data acquisition input channels, 4 analog output channels, and LabView 7 Express data acquisition development system. The systems are portable and can be used in the NEES/SEESL environment as well as in the various teaching labs located throughout CSEE. To take a look at Labview user manual, as well as the manuals for other

equipment available on site please refer to training manuals section of SEESL (nees@buffalo) website.

3.8.5. Dell PC & Data Translation 12 bit Desktop System

The lab supports a varying number of these systems. They are configured as needed for up to 32 channels per PC. As the previously mentioned Dell/LabView systems are being phased into service, these systems will gradually be taken out of service due to obsolescence of hardware and software components.

3.9. Networks

3.9.1. Description

The lab is equipped with a gigabit local area network (LAN) connected to the campus backbone with a fiber gigabit link. All IP addresses on this network are in the 128.205.20.0/24 range. Network ports are located through the lab including ports on the strong floor area, along the shake table trench, and the balcony.

Networking Hardware Configuration:

- 4 x Nortel Baystack 380 10/100/1000 switches
- 3 x Nortel Baystack 450 10/100 switches
- 96 1000Mbps port activations
- 72 100 Mbps port activations

A wireless network (802.11b) covering the entire lab area, collaboration room, and telepresence room is accessible to all NEES users. For security reasons, this network is firewalled and requires authorization. A VPN client is provided for secure communications, and is recommended for all users.

Figure 3.9.1-1:Wireless access point

Wireless Configuration:

- 2 x Cisco Aironet 1200 Access Points
- UB VPN Client (localized version of Cisco VPN Client)

3.9.2. Schematics

3.9.2.1. Wired

The 20net has connections to both Internet1 and Internet2 through the campus backbone. All network connections for the 20net originate at the switching closet in XXX Ketter.

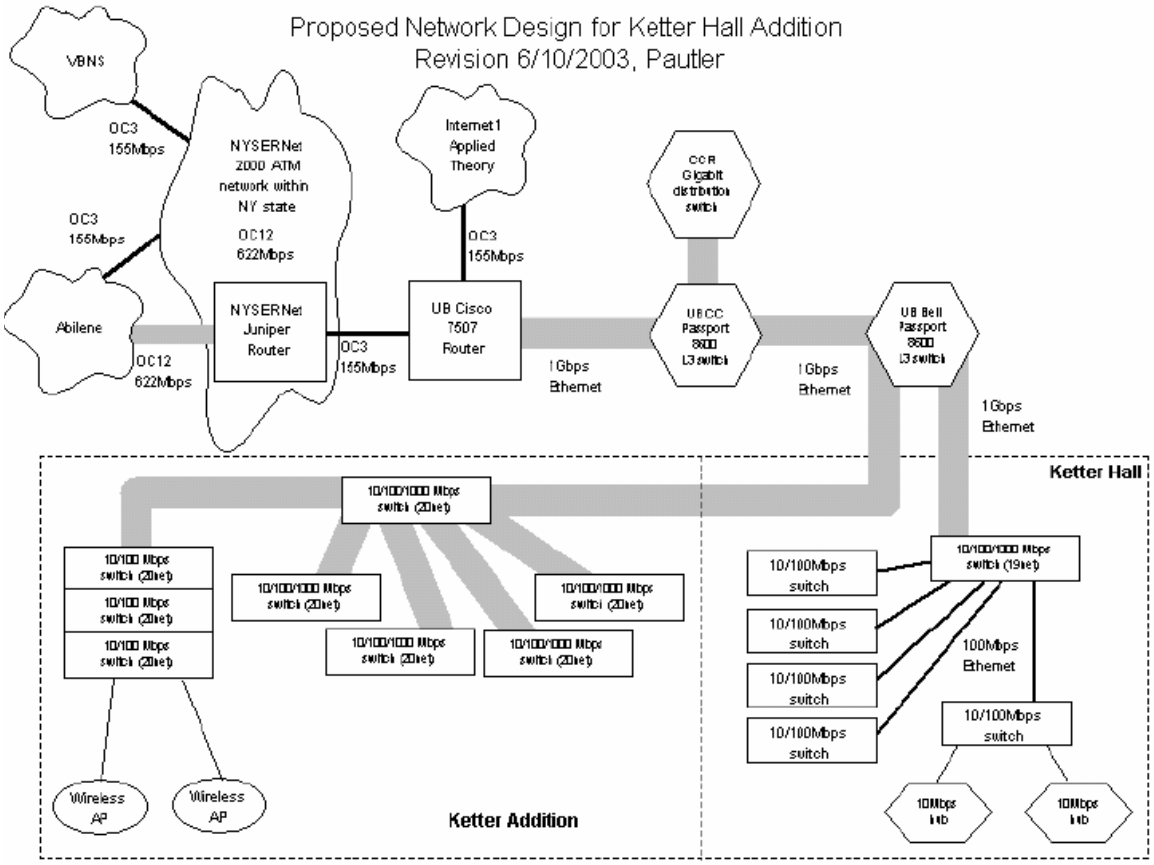


Figure 3.9.2.1-1: Ketter Hall network diagram

3.9.2.2. Wireless

There are two wireless access points located around the SEESL laboratory. Below is a coverage map indicating the quality of the wireless signal within the lab and surrounding areas.

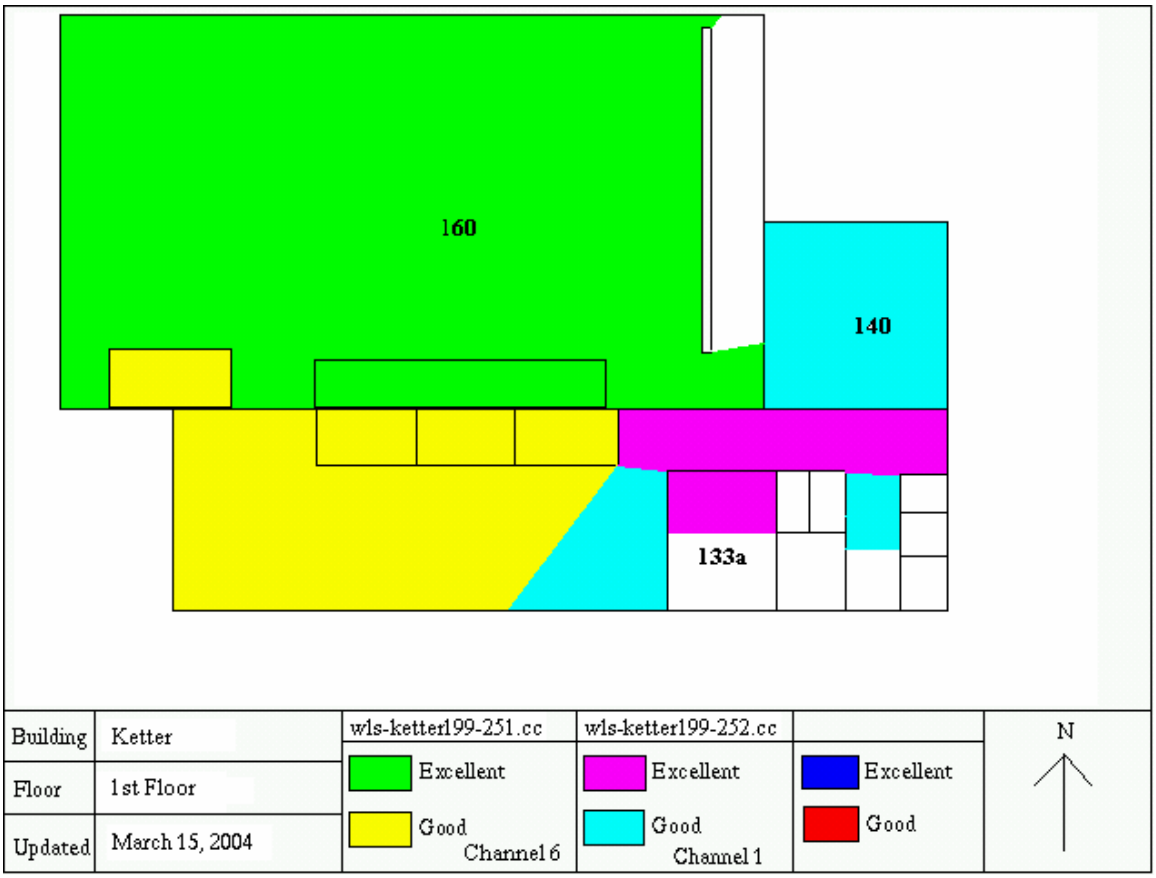


Figure 3.9.2.2-1: Ketter Hall wireless coverage map

3.9.3. Servers

All servers are housed in the server room (161 Ketter Hall), located on the first floor of the lab. Servers are mounted in racks with redundant and backup power supply. Dual gigabit Ethernet connections are provided to each server. There is an integrated LCD/keyboard console to locally administer all servers in the rack.

Figure 3.9.3-1: Server room

3.9.3.1. NEESpop

NEESgrid Point of Presence. The gateway for authorized and secure access to local site resources including telepresence, telecontrol, local data repository, and other collaboration services.

Hardware specifications:

- Dell PowerEdge 2650
- Dual Xenon 2.4GHz Processors
- 100GB RAID 5 Storage
- 2 x Gigabit Ethernet NICs
- 2GB of RAM

Software Specifications:

- Red Hat Enterprise Linux 3.0
- NEESpop 2.2

URL: http://pop.nees.buffalo.edu/

3.9.3.2. NEES TPM

Telepresence server. Manages and provides remote access to all telepresence video/audio streams.

Hardware Specifications:

- Dell PowerEdge 2650
- Dual Xenon 2.4GHz Processors
- 100GB RAID 5 Storage
- 2 x Gigabit Ethernet NICs
- 2GB of RAM

Software Specifications:

- Red Hat Enterprise Linux 3.0
- flexTPS 1.0

URL: http://tpm.nees.buffalo.edu/

3.9.3.3. Webserver & Domain Servers

Host for the nees@Buffalo website and controller of the NEES domain. The domain is controlled by two identical computers to act as backup for each other in case the other one fails.

Hardware Specifications:

- Dell PowerEdge 2650
- Dual Xenon 2.4GHz Processors
- 100GB RAID 5 Storage
- 2 x Gigabit Ethernet NICs
- 2GB of RAM

Software Specifications:

- Windows Server 2003
- IIS 6.0

URL: http://nees.buffalo.edu/

3.9.3.4. Email Server

Hardware Specifications:

- Dell PowerEdge 2600

- Intel Xenon 2.8GHz Processor
- 36GB Storage
- 2 x Gigabit Ethernet NICs
- 2GB of RAM

Software Specifications:

- Windows Server 2003
- CommuniGate Pro
- IIS 6.0

URL: http://webmail.nees.buffalo.edu/

3.9.4. Mass Storage

The lab is equipped with 3.5 TB network-attached storage (NAS) system, Netstor MVD by Excel Meridian. All the data in the storage is being backed up daily on Tape Drives and once a week these backup tapes are taken to an off-site storage site.

Hardware Specification:

- Intel Pentium 4 Xeon 2.4 GHz CPU
- 2 GB DDR PC2100 ECC memory
- 400W hot-swap redundant power
- (2) 10/100/1000Mb Gigabit Copper Ethernet built-in
- (2) Ultra160 SCSI channels, one for external RAID array, one for external Tape Backup device
- (1) 16-bay SATA IDE-to-SCSI RAID solution configured with 16 250 GB SATA drives in RAID5 configuration with hot spare, totaling in 3.5TB capacity.

Figure 3.9.4-1: Front view of Netstor MVD

3.9.4.1. Data Archival and Organization

All test data is archived to the local data repository. Additionally, all configuration information from the data acquisition and control systems is archived there. The local repository is hosted on our NAS system and utilizes our redundant mass storage and backup capabilities.

Access to the data will be provided only to the project members. The project data can be made public or additional users granted access if the project members request it. The data is kept on the local repository for a time determined by the project members. Older data my be moved from the local repository to offline media to ensure the newest data is available online. But all offline data will be made available, on request, in a reasonable time period.

After a test, all data is collected from data acquisition and control systems, and transfered to the local repository. This data includes all the data and configuration files collected from the various data systems, in their original (raw) format. The data is then converted into standard formats, such as ASCII or DADiSP, for use by the researcher. Additional processing may be performed by the researcher and archived in the local repository.

The lab provides a standard template for organization of experimental data. The template provides for archival of additional information used to describe the experiment, such as description of model, instrumentation, data acquisition, and loading system. The template also captures the test plan and implementation details. The local repository may be used by the researcher to store all this additional information in the template.

3.9.5. Telepresence

The lab is equipped with 12 pan/tilt/zoom (PTZ) video cameras for real-time streaming of video from the lab. 4 are permanently mounted in the corners of the lab. 4 are located on telescopic tripods that are relocatable and height adjustable up to 20ft.

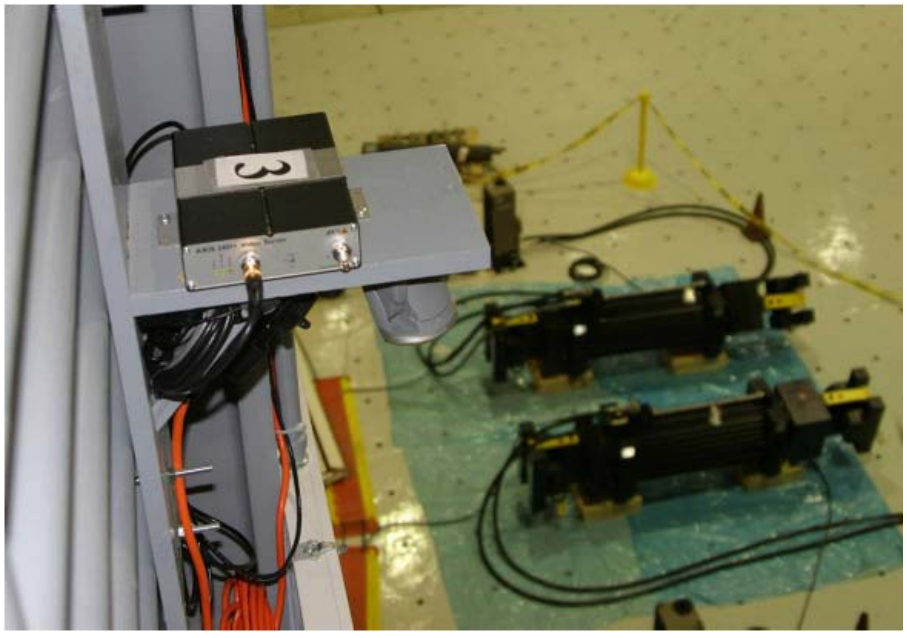


Figure 3.9.5-1: Camera platform mounted in SE corner of lab

Figure 3.9.5-2: Telescopic tripod with camera platform

Hardware Specifications:

- 2 x Axis 2401 Video Servers
- 6 x Axis 2401+ Video Servers
- 4 x Axis 2191 Audio Servers
- 4 x Canon VC-C4R Cameras
- 8 x Canon VC-C4 Cameras

All telepresence video streams are accessible through the flexTPS website. High frame rate video and PTZ camera control require username and password authorization.

3.9.6. Multipurpose Workstations

Workstations capable of controlling any data acquisition or control system in the lab. Preloaded with all the necessary software for any system in the lab. Additionally, software to quickly visualize and analyze captured data is preinstalled.

Hardware Specifications:

- Dell Precision 650
- Intel Xeon 2.66Ghz Processor
- 36GB SCSI Storage
- 2GB of RAM
- 20” Flat Panel Monitor

Software Specifications:

- Windows XP Professional

- PI6000
- LabView
- DADiSP

3.9.7. Computational Workstations

Hardware Specifications:

- Dell Precision 650
- Intel Xeon 2.66Ghz Processor
- 36GB SCSI Storage
- 2GB of RAM
- 20” Flat Panel Monitor

Software Specifications:

- Windows XP Professional
- Matlab
- Microsoft Visual Studio
- SAP
- Larsa
- Idarc
- OpenSees

4. Support facilities

4.1. Teleparticipation / Instructional Room

The Telepresence Room in Ketter Hall (Room 140) is a newly renovated space designed for observation and participation in research at local and remote NEES facilities. Equipped with multimedia and collaborative technologies to facilitate a virtual presence at any remote laboratory.

Projection and Presentation Equipment

Three large projection screens are located in the front of the room to provide multiple views of the same content, or views of different content on each screen. One projection screen also operates as a digital whiteboard giving one the ability to use a digital pen to markup documents and save them electronically. A podium is also located in front of the room with an integrated desktop computer and video, audio, network, and power connections for a notebook computer. An LCD monitor, directed at the podium, is ceiling mounted for use as a feedback monitor by the presenter.

Teleconferencing and Webcasting Equipment

Multimedia presentations can be made and broadcast to remote sites using the internet. Two pan/tilt/zoom video cameras are located in the opposite corners of the room along with wired and wireless microphones to capture what ever is going on in the room. These can be used with video conferencing system to collaborate with other sites using standard H.323 technology. Multipoint videoconferencing is available using local resources with up to 3 remote endpoints and many more using shared Internet2 Commons resources. Webcasting of audio, video and computer content (PowerPoint, etc...) is also available and requires the remote viewer to access a webpage via their web browser to view the multimedia presentation. Digital recordings of any presented material including audio/video/media can be made for use as instructional content.

Other Equipment

In addition normal conference room activities are supported such as viewing of movies in either DVD or VHS format. A visualizer is available for display of printed material. Phone conferences can be held using integrated room microphones and speaker system. Traditional whiteboards are located around the room in each corner. The digital whiteboard can also be used as a traditional whiteboard using standard dry erase markers.

All these capabilities are controlled through a simple LCD touch screen interface located on the podium. A simple set of intuitive menus can be navigated to configure and display any video source on any of the available screens and a feedback monitor. Presenter needs to undergo a simple training process in order to use the basic functions of the room. Other more technical functions will require advanced training or an on-site operator.

4.1.1. Supported Usage

- Seminars
- Personnel Training
- Telepresence
- Data Visualization
- Webcasting
- Video Conferencing

- Phone Conferencing
- Video playback (DVD, VCR, HD, Computer)
- Computer Presentations
- Notebook Presentations

4.1.2. Equipment

- Toshiba TLP-T720U Projectors (x3)
- 80"x60" projection screens (x2)
- 77.5" Digital Whiteboard
- Ceiling mounted LCD feedback monitor
- Polycom VS4000
- Sony EVI-D30 Camera(x2)
- Wireless label mic.(x2)
- Wireless handheld mic.(x2)
- Retractable, ceiling mounted hanging mic.(x5)
- Crestron control system
- Computer(with DVD player)
- VCR
- Visualizer
- Webcast computer
- Whiteboards

4.1.3. Capacity

- 40 people with desks
- 70 people with no desks

4.2. Collaboration Room

The Collaboration Room in Ketter Hall (Room 133) is a newly renovated space designed for visiting researchers who are involved with lab projects. It is equipped with 10 workstations and 2 round tables as to provide for everyday work area as well as collaboration and meeting place.

5. ORGANIZATION

5.1. Laboratory Personnel

5.1.1. Management, operations and maintenance

5.1.1.1. Organization Chart

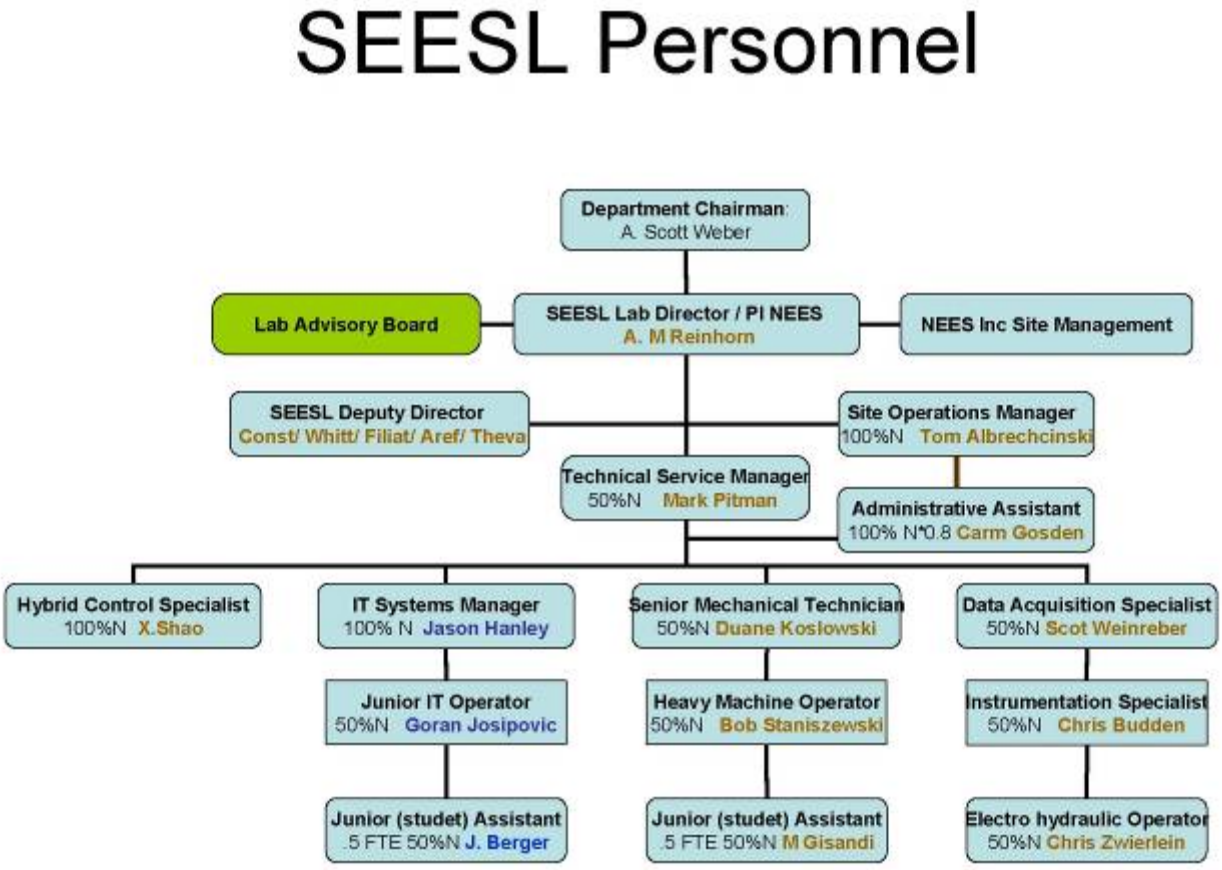


Figure 5.1.1.1-1 SEESL Organization chart

5.1.2. Expert consultants

Prof. Ricardo Dobry (RPI)
Prof. Ahmed Elgamal (UCSD)
Prof. Gregory Fenves (UCBerkeley)
Prof. Masayoshi Nashima (U of Kyoto, Japan)
Dr. Tom Prudhomme (NCSA, UIL)
Dr. Michael A. Riley (NIST)
Prof. P. Benson Shing (UC)
Prof. David Stoten (U of Bristol, UK)
Mr. Douglas P. Taylor (Taylor Devices Inc.)

5.2. Access rules

5.2.1 Lab services

The Structural Engineering and Earthquake Simulation Laboratory (SEESL) at University at Buffalo hosts a series of services for research clients such as planning organizations (i.e. MCEER, NSF/NEES, etc), for industry and industry partners, for faculty and students at Department of Civil Structural and Environmental Engineering at University at Buffalo, and others. SEESL hosts among other services (i) the UB-NEES site of the George E Brown Jr. Network for Earthquake Engineering Simulation, which provides services to the NEES research community. The UB-NEES services are operated with support from NEES Inc. which in turn is supported with a grant from the Division of Civil and Mechanical Systems of National Science Foundation (NSF); (ii) the MCEER structural engineering testing services part of the MCEER users network of experimental facilities; (iii) the CSEE instructional and research testing services on earthquake engineering and structural dynamics; (iv) the research services for other research sponsoring agencies and (iv) the services to industry and other investigative agencies.

SEESL operates equipment developed with funding from NSF and other sources. The equipment developed with funding from NSF / NEES initiative is provided free of charges for users performing research approved by NEES Inc. (defined below as NEES research). SEESL operates the other equipment purchased with other funds that will be available to all researchers (NEES or non-NEES) for a fee as posted below. All SEESL equipment is available for any non-NEES research for fees as indicated in the recharge fees schedule.

5.2.1. Equipment commitments

5.2.3 Access rules ***Specific Safety and Access Requirements***

The complete safety requirements are listed in the **Lab Safety Manual.** The following are excerpts from the **Lab Safety Manual.** The requirements listed below are intended to provide a select but incomplete list of *do* and *do nots*.

(a) General Requirements

- Access in the laboratory is permitted when at least one other person is in the laboratory and he or she has been informed of your presence and is in eye or communication contact with you at all times.
- Know where First Aid Kit, Eye Wash Station, Fire Exits, Fire Extinguishers, and Electrical Disconnects are located.
- Know the location of emergency phones and emergency shut off buttons for the hydraulic system.. Use them at the request of lab personnel or in their absence using your best judgment.
- Keep walkways (which are marked with crosshatched yellow tape) clear of all obstacles at all times.
- Do not block fire extinguishers or electrical panels.
- Clean up work area daily.
- If your work will generate dust, cover sensitive equipment before you start, and clean up the dust. Dust cleaning equipment available in the laboratory.

- At the conclusion of testing, safely remove and dispose of the specimens, within the time-frame agreed to in the WORK PLAN. The researcher remains responsible for the removal operations until this task is complete.

(b)Testing Areas

- When the warning strobe lights are flashing, the hydraulic system is active and testing operations are in progress. Unauthorized personnel must not approach within 10 feet of any hydraulic line, shake table, actuator, or test specimen. Authorization must be obtained from the Technical Services Manager or designated test supervisor
- Authorized personnel, attending a live experiment, must be equipped with a communication device provided by the Technical Services Manager and stay in communication with the test supervisor.
- All other project work may be interrupted, at the direction of the test supervisor, during testing.
- All personnel accessing the basement spaces under the test floor and the service rooms must remain in contact with the test supervisor working above the floor

(c) Cranes, Forklifts, Scissor lifts

- Cranes, forklifts, and scissor lifts may not be used unless the operator has been trained and certified by the laboratory Field Safety Officer or designated staff member.
- Operations involving heavy and/or large items requiring the use of the crane and rigging will be performed only by trained laboratory staff members.
- When the crane is used above the hydraulic actuators, controllers, data acquisition systems or hydraulic systems a second staff member must be present as an observer.
- Cranes shall not be left unattended while still attached to a specimen or test fixture.
- Scissor lifts must be operated / attended by a team of two users at times.

(d) Laboratory Equipment

- The use of power tools is not permitted unless authorized by full time lab personnel.
- Do not move or modify any hydraulic actuators, accumulators, or hydraulic lines. This is only to be done by authorized lab personnel.
- Use of the welder or blow torch is not allowed. These operations are only to be performed by authorized lab personnel.
- All tools must be inspected before use and any defect reported to lab personnel.
- Return tools to the proper location at the end of each working day and when the job is complete.
- Do not use any pre-stressing Jacks. This can be done only by authorized lab personnel.
- Ladders must be properly positioned and/or tied off.

(e) Access to Tools

- The SEESL facility has tools (hand tools, power tools, air tools, and welding tools) that will be made available to NEES and non-NEES researchers who adhere to the requirements noted above and have paid the user fee.
- Power tools can be checked out of the Equipment Room on a daily basis. Hand tools will be available in a kit that can be checked out for the duration of a SEESL project. NEES researchers will be responsible for returning all tools to the Equipment Room in operable condition.

- The electric welder and/or cutting torch may be used by qualified professionals who are hired on a subcontract basis to either fabricate or demolish test specimens. In such cases, prior approval from the Operations Manager must be obtained.
- The subcontractor client wishing to use this equipment will be required to verify professional qualifications and prior experience.
- The NEES project will be responsible for replacing any lost hand tools.
- Recharge fees are required for use of tools by research visitors in SEESL lab. The recharge rates are listed in the Recharge Fees Schedule (see section on Recharge Fees below). Recharge rates are updated annually. NEES researchers will have to budget a minimum of $500 for use of lab tools.
- Current recharge rates can be found on the SEESL website.

(f) Access to Instrumentation

- Instrumentation purchased through NEES is available for free use to NEES researchers. A complete list of NEES instrumentation is identified on the SEESL/UB-NEES Lab Manual. Additional instrumentation may be available for a fee. All instrumentation is available to non-NEES researchers for a fee.
- For safety reasons, only SEESL staff are allowed to operate much of the SEESL Laboratory instruments and equipment. Examples include: hydraulic equipment (e.g., pump, manifolds, controllers, actuators and hoses), forklift, scissors lift, electric arc welder, oxygen-acetylene cutting torch, and all computing equipment (except as outlined in the Access to IT Section), cameras (except as outlined below), and associated cabling (except as outlined below). This policy will be enforced strictly. The only exceptions are use of the electric welder and/or cutting torch (as described in the Access to Tools Section), and data sensors and lighting not attached to robotic arms.
- NEES and Non-NEES data sensors (e.g., linear variable differential transformers, string pots, and other reusable sensors not purchased with project funds), lighting equipment and associated cabling may be checked out of the Equipment Room for the period of time identified in the work plan schedule.
- Calibration of this equipment must be done by the NEES researchers, as needed. SEESL staff will remove and return all reusable NEES and Non-NEES instrumentation, lighting, and associated cabling.
- Video and still image cameras and associated equipment, including robotic arms are to be installed only by SEESL laboratory personnel. SEESL staff will also remove and return all cameras and associated equipment. However, video or still image cameras can be checked out of the Equipment Room on a daily basis during operating hours for short-term use.

(g) Access to the SEESL Controllers

- For safety reasons, only SEESL staff will be allowed to operate the Shake Tables controllers and the STS controllers.
- NEES researchers may have access to the other SEESL controllers for various actuators (see list in the LAB MANUAL) after proper training by lab personnel and with their daily approval.
- NEES Researchers will have access to the Hybrid Testing System after proper training by the lab personnel with assistance of the Lab Technical Staff.

(h) IT Access

- The SEESL/UB-NEES Laboratory is outfitted with a variety of data acquisition, archiving, and tele-presence equipment, including sensors (e.g., load cells, transducers, and cameras), servers, appliances, and cabling.
- Access to all computers is restricted to SEESL personnel with the exception of the data acquisition servers, client machines, SEESL Local Data Repository, and video-teleconferencing equipment (personal computers will not be provided by the SEESL to NEES researchers).
- Accounts on the data acquisition servers, client machines, and the SEESL Laboratory Local Data Repository will be provided to NEES researchers by the Site IT Services Manager on an as-needed basis after training on the equipment is completed.
- The SEESL is linked to computational facilities associated with the NEESgrid. Use of those facilities is administered by the NEES Consortium, Inc.
- The SEESL is connected to the NEES Data Repository. Access to the NEES Data Repository, including curation services, is administered by the NEES Consortium, Inc. SEESL staff will facilitate access to the NEES Data Repository as needed.
- All results and metadata for experiments and simulations conducted within the SEESL will be stored on the SEESL Local Data Repository for a minimum of three months (automatically) and up to a maximum of six months after the termination date of the SEESL research agreement for the pertinent project. Storage requests for a longer period of time than the minimum must receive approval from the Operations Manager.
- The SEESL staff will facilitate access to the SEESL Local Data Repository. However, SEESL staff will not provide curation or data reduction services for a project.

5.2.4 Safety rules

Laboratory safety is the highest priority at SEESL. The Department of Civil, Structural and Environmental Engineering (CSEE) has a **SAFETY PLAN** that covers the operations of SEESL. This **SAFETY PLAN** requires safety training of all employees, students and visitors. Moreover, it requires periodic inspection of laboratories and other spaces for identification and correction of unsafe conditions. The SEESL Site Operations Manager (OM) is responsible implementing the **SAFETY PLAN** and for coordinating the training of employees, students and visitors in the NEES facility. The SEESL ***Deputy Director*** is in charge of development of rules and policies or resolving safety issues in the absence of appropriate policies. The ***Field Safety Officer***, who is a member of the SEESL Technical Staff, serves as the floor supervisor. The Field Safety Officer is empowered to suspend the work or the visit of any person who does not comply with the safety requirements.

All researchers and users of SEESL must undergo safety training prior to starting work in the laboratory. The training can start with a review of the CSEE **Safety Training Manual** (http://nees.buffalo.edu/). Upon arrival at SEESL, the visitor must take the 6-hour training class, which includes a walk through of the facilities and an examination (described below). Each person will be issued a certificate of completion of safety training allowing access to the facility.

All researchers planning to work in the laboratory must wear personal protection equipment (PPE), which includes:

- **Hardhats** are mandatory for all who access the testing floor in the laboratory. Hardhats are not required on the third floor observation deck.
- **Steel toe shoes or boots** are required in all areas of the testing floors. Safety shoes are not required on the observation deck.
- **Gloves** are required whenever assembling or disassembling test specimens or test fixtures.
- **Eyeglasses** are mandatory when grinding, impacting, drilling, mixing or hammering.
- **Earplugs** or earmuffs are mandatory and available from a member of the SEESL Technical Staff when grinding, impacting, or drilling.

- A personal **safety harness** shall be used when and where required member of the SEESL Technical Staff

The laboratory will provide hard hats, gloves, eye protection goggles, earplugs and safety harnesses for short term visitors. Safety shoes must be provided by the researcher or user

5.2.5 Access fees

(I) Facilities, equipment and services available to **NEES researchers without fees**:

(a) Two six-degree of freedom earthquake simulators, each with a payload of 50 tons (100 tons combined); for a complete performance description visit http://nees.buffalo.edu/.
(b) Three high-performance dynamic actuators (1000 kN capacity, ± 500 mm stroke, 1 m/s velocity, 800 gpm servo-valves), equipped with load cells and displacement transducers.
(c) Two static actuators (± 2000 kN capacity, ± 500mm stroke), equipped with displacement transducers.
(d) Data acquisition systems consisting of up to 250 channels streaming and additional 100 channels local.
(e) An advanced Krypton 3D coordinate tracking system with up to 15 LED targets.
(f) A 285m^2 (300 sq.ft) new strong floor with 610 x 610 mm (2 x 2 ft) tie-down grid.
(g) A 19.5 x 9 m (60 x 30 ft) strong reaction wall with 610 x 610 mm (2 x 2 ft) tie-down grid.
(h) A 6 x 2.5 m plan x 6 m high (20 x 8 x 20 ft) laminar box which can be mounted on shake table(s) – for complete performance and users guide visit http://nees.buffalo.edu/
(i) A 40 ton crane to move equipment and specimens anywhere within the 900 m^2 of the building housing the two shake tables, the strong floor, and the strong reaction wall.
(j) 50 m^2, 9 person capacity collaboration room with tele-observation and tele-participation capabilities (subject to the constraints presented below).
(k) Room with videoconference capabilities (prior scheduling required: calendar)
(l) Office space for students (subject to the constraints presented below: scheduling will be done with the Site Operation Manager).
(m) Office space for faculty members (subject to the constraints presented below: scheduling will be done with the Site Operation Manager).
(n) All computational facilities of the UB-NEES node.

Note that these facilities and equipment are unique and may not be available due to use on other projects. Careful planning and scheduling is required.

(II) Facilities, equipment, and services available to all (including NEES) researchers **for a fee** consist of:

(a) Accelerometers (total of 63), displacement transducers (total of 70 with capacities ranging from 100 mm to 300 mm), and load cells (total of 34 with 5 multi-component cells with 200kN axial load capacity and 90kN shear load capacity). - Several instruments will be free of charge for NEES researchers as indicated in the website LAB MANUAL.
(b) A third 5 degree of freedom earthquake simulator with a maximum payload of 50 tons with performance capabilities similar to the simulators described on page 1 above. .
(c) A small isolation bearing testing machine with 600 kN vertical load capacity, ± 150 mm stroke and 0.4 m/sec velocity.
(d) A large isolation bearing testing machine with 7000 kN axial load capacity, ± 125mm stroke and .25 m/sec velocity.
(e) Ten hydraulic actuators with 10 to 1000 kN load capacity, ± 50 to ± 300mm stroke and maximum velocity of 1.75 m/sec.

(f) Manifolds, controllers, and all equipment needed for the control of the actuators in item (e) above.
(g) Two portable data acquisition systems, each with a capacity of 12 channels.
(h) X-Y recorders, frequency analyzers, portable measuring devices, oscilloscopes, digital multimeters, borescopes, thickness measuring devices, roughness measuring instruments, etc.
(i) A 30 m^3 environmental chamber capable of sustaining temperatures in the range of -40^{o}C to 50^{o}C.
(j) A quarter length scale six-story steel model structure with 200 kN weight for use in earthquake- simulator testing.
(k) A quarter length scale steel bridge model with 150 kN weight and featuring flexible or stiff piers for use in earthquake-simulator testing.
(l) A versatile, quarter length scale steel model that can be configured in a variety of configurations, including 3-bay, 3-story building and one-bay, 6-story building.
(m) Welding equipment, hydraulic jacks, forklifts, rigging equipment, etc.
(n) Heavy hand and machine tools.
(o) Technical services for assembly of specimens.
(p) Instrumentation modification and calibration services.
(q) The University at Buffalo library facilities during the duration of stay (subject to the limitations listed below).
(r) Parking space at the University at Buffalo parking facilities for a nominal fee (typically less than $5 per year) during the duration of (subject to the limitations listed below).

Note that these facilities and equipment may not be available for use. Careful planning and scheduling is required.

Recharge Rates - Fees

The use of the SEESL equipment by either NEES or non-NEES researchers require budgeting according to rates approved by University at Buffalo.

For NEES sponsored projects the majority of operation and maintenance costs are anticipated to be covered by the NEES O&M contract between NEES and the University at Buffalo. The O&M contract will not be finalized until NSF approves the overall NEES budget request, consequently this may affect the recharge fee for NEES services.

If NEES fully funds our O&M proposal and its amendments, limited recharge fee would be needed for tools and rigging equipment. However if these items are not fully funded the SEESL/UB-NEES will charge a minimum of $1500 a month for lab space, rigging equipment and tools.

Until budgets are finalized researchers should assemble proposals with a $1500 a month fee for tool use etc.

If NEES or other non-NEES “fee free” projects exceed the time allocation in the agreed schedule, the researchers will be charged fees as for non-NEES project.

The **Recharge Fees Schedule** (see below) for all research users is available also from the webpage http://nees.buffalo.edu/ and is updated periodically. All fees are subjected to overhead at current rates of University at Buffalo (57% as of October 1, 2004). The overhead rates change periodically. Before completing any budget check this document for updates.

Resources

A service agreement prepared before the work can start at SEESL/UB-NEES, developed between the SEESL and the researchers’ HOME INSTITUTION, will establish the NEES resources to be utilized in the laboratory work and the non-NEES resources required for the completion of the research. If the latter

are required the agreements will include a detailed description of the fees, and a payment schedule. The agreement will be signed by the authorized representative of the visiting researcher's HOME INSTITUTION and the SEESL representative (a member of the Sponsored Programs Administration of the University at Buffalo)

Agreements

An agreement will be executed between the visiting researcher's HOME INSTITUTION and SEESL represented by a member of the Sponsored Programs Administration. The agreement will incorporate by reference all of the rules and requirements of this document. The list below summarizes the issues to be addressed by the agreement:

- Work Plan (including the requests for equipment, space, personnel)
- Safety requirements
- Insurance and liability
- Access to facilities
- Resources needed and budget recovery mechanism
- Schedules

The agreement can follow a **template** available on the website in the Site Access Plan along with additional information and /or modifications will be utilized. The agreement can be developed with the assistance of the **Site Operations Manager** and other key Lab Personnel. The agreement must be signed prior to the start of actual work at SEESL/UB-NEES

Table 1: Operations and Maintenance Recharge Fees for SEESL

Operations and Maintenance Recharge Fees for SEESL:						
OVERHEAD SHOULD BE ADDED TO THE ABOVE FEES AT THE OFFICIAL UNIVERSITY AT BUFFALO RATES.						
	CURRENT OVERHEAD RATES (October1, 2004)	57%		57%		
		Research Fees				
		Sponsored Research*	Non-NEES	Sponsored Research* NEES**		
		Fees for Labor / Technical Assistance- per day (minimum 1/2 day)				
		Daily	Hourly	Daily	Hourly	Fringe benefits included in the basic fees
1	Engineering aid*	$190	$25	**$190**	**$25**	
2	Expert Student (grad) Consultant	$280	$35	**$280**	**$35**	
3	Lab Technician (Majewski)	$290	$35	**$290**	**$35**	
4	Lab Specialist (Weinreb, Koslowski, Budden, Staniszevski)	$350	$45			
5	Development engineer / operator (Pitman)	$460	$60			
6	Expert Testing Consultant	$1,010	$125	**$1,010**	**$125**	
		Fees for Equipment Usage				
		Sponsored Research*	Non-NEES	Sponsored Research* NEES**		
Item	Equipment	Full Usage	Idle Occupancy	Full Usage	Idle Occupancy	
	TESTING SYSTEMS					
1	**Shake Table 1 or 2 (6-DOF)**	**$1,750**	**$875**			
2	**Shake Table 2 with reaction wall (6-DOF)**	**$1,800**	**$900**			
3	**Shake Table 1 and 2 (6-DOF)**	**$3,500**	**$1,750**			
4	Shake Table 5-DOF	**$1,700**	**$850**	$1,700	$850	

5	Shake Table (Small)	**$400**	**$200**	$400	$200	
6	Bearing Testing Machine (large)	**$300**	**$60**	$300	$60	
7	Bearing Testing Machine (small)	**$200**	**$40**	$200	$40	
8	Reaction Frame (large)	**$300**	**$60**	$300	$60	
9	Reaction Frame (small)	**$100**	**$20**	$100	$20	
10	**Reaction Wall**	**$300**	**$60**			
	TEST APARATUS					
11	140 ton - UTM-Tinius Olsen Machine	**$60**	**$10**	$60	$10	
12	110 ton -UTM - MTS	**$100**	**$20**	$100	$20	
13	Axial - Torsion MTS apparatus	**$200**	**$40**	$200	$40	
	ACTUATORS with CONTROLLERS					
14	**Actuators-dynamic high capacity >=100 tons**	**$600**	**$120**			
15	Actuators-dynamic medium capacity 20<100 tons	**$300**	**$60**	$300	$60	
16	Actuators-dynamic small capacity <20 tons	**$200**	**$40**	$200	$40	
17	**Actuators-static high capacity >=140 tons**	**$300**	**$60**			
18	Actuators-static medium capacity 30<140 tons	**$200**	**$40**	$200	$40	
19	Actuators-static small capacity <20 tons	**$100**	**$20**	$100	$20	
	HYDRAULIC EQUIPMENT					
20	Hand Pumps	**$40**	**$20**	$40	$20	
21	Servovalves substitutions	**$40**	**$20**	$40	$20	
22	Hydraulic manifolds - substitutions	**$90**	**$45**	$90	$45	
	CONTROLLERS					
23	**FlexTest**	**$900**	**$180**			
24	**Hybrid Controller**	**$1,200**	**$240**			
25	PID controllers - substitutions	**$30**	**$5**	$30	$5	
	MODELS					
26	Bridge Model - one span ***	**$100**	**$20**	$100	$20	
27	7 Stories Model***	**$300**	**$30**	$300	$30	
28	6 Stories Model***	**$300**	**$30**	$300	$30	
29	5 Stories Model***	**$300**	**$30**	$300	$30	
30	Reconfigurable 1 - 6 stories model***	**$300**	**$30**	$300	$30	
31	Interface Block	**$10**				
	INSTRUMENTATION (with conditioners)					
32	Accelerometers, LVDT's, potentiometers - up to 20 sensors	**$110**	**$28**	$110	$28	
33	Accelerometers, LVDT's, potentiometers - additional 5 sensors	**$25**	**$5**	$25	$5	
34	Load Cells (uniaxial and multiaxial) - per axis	**$10**	**$5**	$10	$5	
35	**Krypton 3D remote sensing system**	**$200**	**$40**			
36	**Digital camera or video**	**$10**	**$5**			
	VIDEORECORDING AND STREAMING					
37	**Videocamera**	**$30**	**$15**			
38	**Still camera**	**$30**	**$15**			
39	**Conferencing equipment**	**$100**	**$25**			
	DATA ACQUISITION					
40	Portable data acquisition - 16 channels	**$20**	**$5**	$20	$5	
41	**Data Acquisition - up to 75 channels**	**$210**	**$40**			
42	**Data Acquisition - over 75 chanels- fee per channel**	**$2**				
	OCCUPANCY*					
43	Floor occupancy per 50 sq.ft* increment /day	**$180**		**$180**		
44	Storage of large models / per day***	**$30**		$30		
45	Small model removal deposit - minimum / model one time fee	**$1,000**		$1,000		
46	Large model removal deposit .>=$1000 one time fee	**negociated**		negociated		

The rates include overhead for laboratory intangibles

*** Ocupancy charges apply to usage of space beyond the originally scheduled time**

**** Fees will not be applied to scheduled NEES projects.**

For all extra unscheduled time of NEES projects, fees will be charged using Non-NEES rates.

Technician time will be charged for activities not supported by NEES maintenance contract.

*** Additional fee of $300 should be added for moving from and to storage		
OVERHEAD SHOULD BE ADDED TO THE ABOVE FEES AT THE OFFICIAL UNIVERSITY AT BUFFALO RATES.		
CURRENT OVERHEAD RATES (October1, 2004)	57%	57%

5.3. Scheduling

5.3.1 Scheduling rules

Project Planning / Work Plan:

All researchers planning to access the SEESL site must follow the NEES Inc. guidelines for access to NEES research facilities. The following are minimum requirements for such access.

The key element to safe and efficient use of the SEESL equipment, the lab space, and the associated facilities is the project **WORK PLAN**. A detailed **WORK PLAN** must be prepared by all users and this plan must be approved in advance of work by the Site Operation Manager. The work plan will be incorporated into the contract between the user and the University at Buffalo on behalf of SEESL.

During the award process all principal investigators / researchers must submit the **WORK PLAN** indicating the test set-up including fail safe system required, the equipment and instrumentation required, the testing protocol intended, specimen demolition, detailed information concerning the individual work tasks to be performed, the duration of the tasks, the order in which the tasks are to be performed, who will perform the tasks, and the resources required to perform the tasks. A comprehensive schedule with milestones related to the project schedule shall be submitted with the **WORK PLAN**. The plan should address data management and archival needs . The following is an itemized list of issues that must be addressed in the **WORK PLAN:**

1. A list of tasks to be performed
2. Specimen and fail safe system drawings
3. Calculations for the specimen and failsafe system
4. An instrumentation plan
5. A testing plan
6. List of equipment, materials, supplies, tools and personnel to carry out the work tasks
7. Space requirements including lab and office space
8. A rigging plan including disposal of specimens after testing
9. A plan for data management and IT requirements
10. Schedule of tasks including duration and timing

All experiments to be performed using the SEESL/UB-NEES equipment should be carefully planned to assure the safety of equipment, operators, and all other users of the laboratory. All researchers should develop detailed plans for the tests set-ups which must include provisions for fail safe of experiment components and equipment. Detailed construction plans for all specimens and test fixtures designed by the visiting researchers must be provided. The plans must include the detailed design of **the fail-safe system**. Each testing arrangement and specimen must be reviewed and certified (stamped) by a Professional Engineer with experience in dynamic testing (or with demonstrated equivalent qualifications). The SEESL Site Operations Manager (OM) will review the **completeness** of submittal. The Site Operation Manager will work with visiting researchers, review testing plans, and help visiting researchers demonstrate and document that their testing apparatuses satisfy OSHA in full and the State and Campus safety requirements. The Site Operation Manager will be the point of contact for users of SEESL and will provide the information needed to develop a **WORK PLAN**. Note that the safety of the test set-up and of the SEESL equipment will remain the responsibility of the researcher or user.

The NEES researchers will have to negotiate with the NEES Inc. staff a schedule that will be agreed to jointly with SEESL staff. For any time in excess of that negotiated with NEES Inc., fees will be charged at

the rates charged for non-NEES projects. The scheduling for NEES researchers will be negotiated with the NEESinc Operations Manager and with the SEESL / NEES Site Operations Manager.

Non-NEES researchers will have to negotiate their schedule directly with SEESL Site Operations Manager.

Once activity begins in SEESL, the researcher or user (NEES or non–NEES) must update the **WORK PLAN** weekly and submit any changes for review and approval by the Site Operations Manager.

Failure to follow policies regarding safety or the **WORK PLAN** will result in the following consequences:

- First offense – verbal reminder
- Second offense – written notification of out of scope work, or safety violation
- Third offense – suspension of work and a mandatory review of both safety and **WORK PLAN**. The results of the review of *NEES research projects* will be submitted to the NEESInc for further action. *Non-NEES research* may be terminated directly by SEESL management.

Note: Lab Personnel have the right to stop, or refuse, any task or any operation performed with any equipment used by any Lab User.

Schedules

SEESL / UB-NEES is a shared facility which provides services to many entities. SEESL is committed to share all the NEES equipment and facility up to 50% as required by the Management Operations and Maintenance (MO&M) contract with NEES Inc. and NSF/NEES. In order to accommodate all projects a carefully developed schedule agreement between the researcher and SEESL is required. At the request of the researcher the Site Operations manager will develop a schedule which will have to be coordinated with NEES Inc. (for NEES projects) or with the SEESL Director (for non-NEES projects). The schedule will be then included in an agreement as indicated below. The schedule will include all elements requested in the **Work Plan**

Failure to obey the agreed schedule may result in additional fees at non-NEES rates for the exceeding period (applied to all researchers). The agreement will include assurances that such fees will be paid to SEESL. In case of major slip in schedule the work may be indefinitely postponed and a new schedule will have to be negotiated jointly with NEES Inc. and the Site Operations Manager.

Business Calendar/Hours

The SEESL laboratory follows the official schedule of the University at Buffalo, including its holiday schedule. The laboratory is open 5 days a week between 8:00 am to 4:30 pm. Work after hours or weekends might be possible in special cases with prior approval of the Site Operation Manager. Special safety restrictions and requirements will apply to such work.

5.3.1. Current Schedule

For the current schedule please visit scheduling portion of SEESL (nees@buffalo) website

6. Past experiments

6.1. Seismic Resistance of Reinforced Concrete Frame Structures Designed Only for Gravity Loads

6.2. NCEER-92-0027 December 1992*

6.3. Seismic Qualification For Coupling Capacitor Voltage Transformer

6.4. Westinghouse Electric Corp., March 1989

6.5. Qualification Testing for Transportation Container

6.6. Erie Products, Buffalo, NY*

6.7. Testing of 7-Story Isolated Building Model

6.8. NCEER-94-0007 1994*

6.9. Experimental Study of Active Control of MDOF Structures Under Seismic Excitations

6.10. NCEER-88-0025 July 1988*

6.11. Experimental and Analytical Investigation of Seismic Retrofit of Structures with Supplemental Damping

6.12. NCEER-95-0001 January 1995*

6.13. Earthquake Simulation Tests of a Low-Rise Metal Structure

6.14. NCEER-88-0026*

6.15. Sandbox

6.16. Qualification for Station Post Insulators : Solid Core : Subjected to Lateral (Cantilever) Loading

6.17. ABB Corp., July 1990*

6.18. Evaluation of Tyfo-S Fiber Wrap System For Out of Plane Strengthening of Masonry Walls

6.19. R.J. Watson, Inc., March 1995*

6.20. Damping Test for 500 kV DC Capacitor Bank

6.21. Westinghouse, April 1988*

6.22. Testing of Bridge Seismic Isolation Systems

6.23. NCEER-93-0020, NCEER-94-0002, NCEER-94-0014, NCEER-94-0022*

6.24. Prototype Testing of Viscous Dampers for San Bernardino Medical Complex

6.25. Taylor Devices, Inc., 1994*

6.26. Experimental Study of Fluid Viscous Dampers in Buildings

6.27. NCEER-92-0032*

6.28. Development and Testing of Energy Dissipation Systems for Stiff Structures

6.29. The Center for Industrial Effectiveness and Taylor Devices, Inc., 1997

6.30. Development and Testing of a Semi-Active Damping System

6.31. NCEER-95-0011*

6.32. Testing of Elastomeric Bearings

6.33. Scougal Rubber Corporation, 1996-1997*

6.34. Testing of Sliding Bearings

6.35. Dynamic Isolation Systems, Inc., 1997*

6.36. Testing of Electronic Equipment and Computers

6.37. NCEER-92-0012, NCEER-93-0007, NCEER-94-0020*

6.38. Qualification Tests of Viscoelastic Dampers

6.39. Navy Building #116 : San Diego, CA*

6.40. Optimal Passive Support Design of Flexibly Supported Pipelines

6.41. Axial Torsion MTS Hydraulic Testing Machine

6.42. Dynamic Testing of Small Components

6.43. Experimental Testing of Active Control Systems Using 62-kip, 6 DOF Model Structure, NCEER-89-0026, 1989*

6.44. Full-scale Implementation of Viscoelastic Dampers

6.45. Seismic Response of a 2/5-scale Steel Structure with Added Viscoelastic Dampers

6.46. NCEER-91-0012, 1991* and NCEER-93-0009, 1993*

6.47. Testing of Water Heaters for Possible Seismic Damage

6.48. NIST GCR 97-732, 1997*

6.49. Laboratory Testing of Base Isolators for Train-induced Vibration Suppression

6.50. Experimental Verification of Active Control Systems for Nanjing Communication Tower

6.51. Full-scale Testing of Active Control Systems

6.52. NCEER 92-0020, 1992